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Pradeep Disanayake



Faculty of Architecture Research Unit
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Sri Lanka

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The peer reviewed and accepted research papers of the conference are included in this volume

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Editor's Note

I am privileged to welcome all participants of the International Research Symposium of the Faculty of the Architecture Research Unit (FARU 2014) for the third consecutive year. With this research symposium, FARU marks eight years of success. On behalf of the Faculty of Architecture Research Unit, I congratulate all the presenters who managed to develop their research to a level admired by a panel of well-known referees from a variety of subject areas.

The theme of this year's symposium, 'Practice Based Research: Exploring Built Environment through Evidence' has been selected for its relevance and the need of the day. The relevance is highlighted in a context that research in academic institutions is gradually deviating from their association with the industry and its practices. The need arises with the increasing demand from the industry to look into enormous and ever complicated issues encountered by professionals in practice. Hence, maintaining links between the two is not an option but has throughout been a necessity for academia. Leonardo da Vinci's Vitruvius Man is an ideal example of the perpetual worldly wisdom associated with historic practices evolved from self driven and self-helped research. For Vitruvius and to his followers' human body was a laboratory to experiment universal compositions and to develop primary axioms for their practices, and the vice-versa. Therefore, it is regarded as an all time reflection of the eternal links between research and practice.

The aim of this symposium is to open up a forum for a wide range of research and scholarly work from the disciplines of Architecture, Building Sciences, Environmental Design, Engineering, Facilities Management, Landscape, Product Design, Project Management, Technology and Town Planning. The symposium is privileged to have Professor Pradumya Vyas, the Director of the National Institute of Design, Ahamedabad, India to deliver the key note. The symposium will be graced by many enlightening presentations and discussions.

At this moment, FARU is grateful to Professor Ananada Jayawardane, Vice Chancellor of the University and the Chief Guest of this event, Professor P K S Mahanama, former Dean of the Faculty of Architecture, Professor Lalith de Silva, Newly elected Dean of the Faculty of Architecture for their support and encouragement towards the development research activities of the University. FARU 2014 wouldn't have been a reality without the support of the Academic and Non-Academic staff of the Faculty of Architecture, the members of the Scientific Committee, sponsors of the event, the Management of Koggala Long Beach Resort, Sri Lanka Navy and also those who provided various support and words of encouragement. Our gratitude is paid to all of them.

Dr. Jagath Munasinghe
Director, Faculty of Architecture Research Unit
Faculty of Architecture
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Message from the Dean, Faculty of Architecture

It is a great pleasure for me to have the opportunity to write this message for the seventh research symposium of the Faculty of Architecture Research Unit (FARU), University of Moratuwa. The research culture in the Faculty of Architecture has been growing over the years and faculty has acquired recognition through teaching, research and consultancies. Research activities are carried out at three levels; i.e. Faculty level, Department level and Individual level. Major mode of presenting research carried at Faculty level is to hold the annual research conference on a theme related to built environment. It has been decided by the Faculty to hold an International Symposium similarly to the previous years to provide a platform for wider range of research and scholarly work carried out by local and international researchers and practitioners who are involved in Architecture, Building Sciences, Environmental Design, Engineering, Facilities Management, Landscape architecture, Product design, Project Management Technology and Planning.

The theme of this year's symposium is the "Practice Based Research: Exploring Built Environment through evidence." As a result of the rapid change in built environment, which had been emerged during the last quarter of the twentieth century, most of the countries have experienced challenges to manage their built environments. The prominent issues of this trend includes the loss of identities of places and the socio-cultural inferences, over emphasis on technology and communication, imbalances on natural systems and resultant natural disasters, failure to adapt for climate change, interference of politics and lack of good governance and national and global economic crises. It is important to address these issues at a greater depth in order to bring out the intellectual discourse at this symposium. It will also deliberate on the emerging issues related to the built environment and outline the future directions to create a sustainable built environment we live in.

In this context, FARU 2014, the seventh annual research symposium of the Faculty of Architecture Research Unit (FARU) of the University of Moratuwa, Sri Lanka intends to open up a forum for a wider range of research and scholarly work on the latest advancements of all future oriented disciplines including Architecture, Building Economics, Construction, Environmental Planning, Facilities Management, Landscape Design, Product and Fashion Design, Project Management, Technology, Urban Planning and Urban Design. A wider participation of both local and international research scholars and practitioners with high level of contribution, in the form of presenting papers and attending intellectual discussions is expected.

I am sure that Faculty of Architecture Research symposium 2014 would be an important milestone to expand the prospect of research carried out by the staff and students of our faculty.

I wish FARU Symposium 2014 all success.

Prof. P.K.S. Mahanama
Dean, Faculty of Architecture
University of Moratuwa
Sri Lanka

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Suitability of Construction Management as a Procurement Method for the Construction of Hotels in Sri Lanka

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Abstract

The Construction Industry is the backbone of the economy of any country. The procurement method chosen for its activities has a significant effect on its performance. Traditional systems practiced in the past have been subject to much criticism over the years and they therefore have now been replaced with several alternative methods. The Construction Management (CM) is one such alternative method. The literature already available on this subject indicates that the CM is suitable for fast-track projects that handle the construction of hospitals and hotels. In Sri Lanka, the demand for hotels is increasing exponentially. Therefore, this research aims at investigating the suitability of CM as a procurement method for hotel building construction in Sri Lanka and at proposing a form of CM suitable for the construction of hotels in Sri Lanka if CM itself is found suitable for this work. The research commenced with a literature survey. Subsequently, semi-structured interviews and questionnaire surveys were carried out. Content analyses and multi-attribute methods were used for the data analysis. The study reveals that CM is a 'moderately suitable' procurement method for the construction of hotels in Sri Lanka.

Keywords: Construction Management, Hotel Building Construction, Procurement Systems.

INTRODUCTION

Background

The Construction Industry is considered as the backbone of the economy of any country (Kumaresan, 2010). The procurement method selected significantly influences the performance of the Construction Industry (Luu, Ng, & Chen, 2003). In the past, Traditional Procurement systems were the most preferred. (Cheung, Yiu, & Chim, 2006). However, in the recent years, these procurement methods have been subject to much criticism due to several reasons (Dali, 2013). As a means of overcoming this criticism, alternative procurement methods have now been introduced (Rameezdeen, 2007). Construction Management (CM) is one such alternative procurement method coming under the category of Management Oriented Procurement Systems (Damayanthi, 2009). Marines (2010) has suggested that CM is suitable for fast track projects involving renovation, extension and construction of hospitals and hotel buildings.

According to data made available by the Sri Lanka Tourism Development Authority (SLTDA, 2012), the construction of hotel buildings is on the increase in Sri Lanka because of the high demand that exists for hotels from tourists who arrive in the country (SLTDA, 2012). So far, in Sri Lanka there have been only a few projects that have used CM procurement approaches (Weeraman, 1992). Therefore, a study about the suitability of CM as a procurement method for the construction of hotel buildings in Sri Lanka has become necessary in order to fill the gap in the literature and to face the demands of the tourist industry which if expanded can rapidly boost the country's economy.

Aim and objectives

The aim of this research is to assess the suitability of CM as a procurement method for the construction of hotel buildings in Sri Lanka having the following as its objectives;

- Identification of different types of procurement methods available in the Construction Industry

- Identification of the unique characteristics of hotel building construction to consider as procurement selection factors
- Analysis of the suitability of CM as a procurement method for the construction of hotel buildings

LITERATURE REVIEW

Overview of procurement systems in the Construction Industry

The word 'Procurement' as applicable to the Construction Industry Has been defined by several authors (Love, Skitmore, & Earl, 1998; Masterman, 2002; Rashid, Taib, Ahmad, Nasid, Ali, & Zainordin., 2006). Recently, Dewage (2009) has simply defined it as the procedure adopted to procure construction work. In the literature, Ratnasabhpathy (2006); Ashworth and Hogg (2007) and many other authors have categorized procurement systems into four comprehensive categories, viz., Separated Systems, Integrated Systems, Management Oriented Systems; and Collaborative Systems.

Separated procurement systems

These systems are also recognized as 'traditional' systems (Uher & Davenport, 2002). In these systems there is a clear and rigid separation between the design and the construction stages (Oyegoke, Dickinson, Malik, McDermott, & Rowlinson, 2009). The most common variants of these Systems are the lump sum, measure and pay, prime cost (cost reimbursement) and schedule of rates contracts (Rowlinson, 1999).

Integrated procurement systems

In an Integrated System the design and the construction stages integrate with each other (Wijewardana, Jayasena, & Ranadewa, 2013). According to McDermott (1999), the general variants of the system are the Design and Build, Novated Design and Build, Turnkey, Package Deal, Design and Construct and Concession Contracts.

2.1.3 Collaborative procurement systems

The simple concept behind Collaborative Systems is the collaboration that exists between or among two or more parties towards attaining project objectives successfully through rational relationships, commitment, and collective investment (Bagnall, 1999). According to Wijewardana et al. (2013) partnering is the latest collaborative system that has received global attention considerably. Harris and McCaffer (2001) have specified the common variants to the Collaborative Systems as Joint Ventures, Partnering, Alliancing (Single target out-turn cost), Voluntary Arrangements and New Engineering.

Management oriented procurement systems

The crucial feature of these systems is the addition of a separate management layer into the design and construction (Rameezdeen & De Silva, 2002). Hence, under these arrangements, the client enters into a Contract Agreement with an organization, which will be held responsible for the management and the coordination of both the design and the construction of the work for a fee (Ratnasabhpathy, 2006). In the literature, Kovacs (2004); Ferry and Brandon (2007); Ashworth and Hogg (2007); and Rameezdeen and Ratnasabhpathy (2007) have defined the Management Oriented Procurement System with CM and Management Contracting as variants.

Construction management procurement method

CM is a project delivery system that was introduced in the 1960's in the UK (Oyegoke, 2001). In the literature, several authors have proved the success of the system which, although practiced to a limited extent in the 1930's had gained popularity in the 1980's and 1990's (Oyegoke, 2001).

Contractual arrangement of construction management

Although Management Contracts and CM contracts are very similar to each other in many respects, there is one fundamental distinction, as shown in Figure 1, between the two Systems (Hackett, Robinson, & Statham, 2007) with regard to the contractual arrangements between the parties.

According to the explanation given by Hackett et al. (2007), in Management Contracting, the Works Contractors or the Package Contractors are in contract with the Management Contractor whereas in CM, none of the Work Contractors or the Package Contractors will enter into a Contract with the Construction Manager with all their contracts being with the Employer.

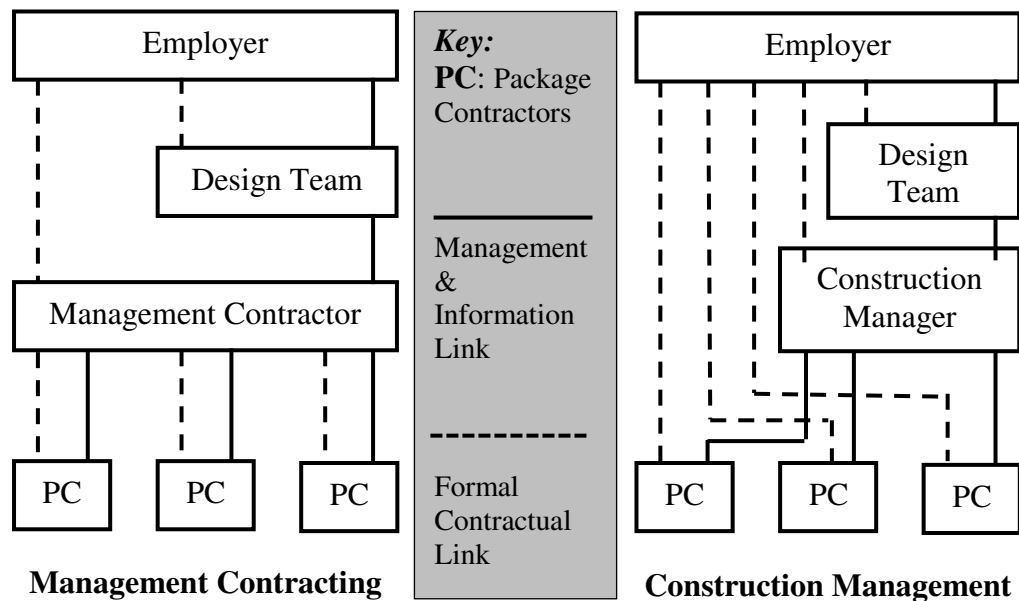


Figure 1: Differing contractual arrangements
 (Source: Hackett, Robinson, & Statham, 2007)

Construction management procurement methods practiced in Sri Lanka

A recent study by Joseph and Jayasena (2008) reveals that Management Contracting has recorded a usage rate of only 1% during the period 1977-2003, and that only a few complex and large projects have been procured using this method.

Table 1: Trend of the use of construction procurement systems in Sri Lanka

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

(Source: Joseph & Jayasena, 2008)

According to the same study, CM has not been used for very long and thus it as a such CM Procurement Method could be considered as quite new to Sri Lanka. Therefore, knowledge on the CM Procurement Method becomes necessary if one is to analyse the suitability of CM to hotel building construction in Sri Lanka.

Overview of the hotel sector

Facilities offering hospitality to travelers have always been a feature of the ancient civilizations (Bonvin, 2003). Gallop (2003) explains that for a period of about 200 years in the mid-17th century, coaching inns provided lodging for coach travelers. Gross (2012) states that the accommodation provided by hotels those days consisted only of a room with a bed, a cupboard, a small table and a washstand. However, nowadays hotels provide rooms with modern facilities which include en-suite bathrooms, air conditioning or climate control, telecommunications and messaging facilities etc. (Gupta & Maurya, 2014).

Uniqueness and specialty of hotel building construction

Hotel buildings are unique as compared to other types of commercial buildings (Priyadarsini, Xuchao, & Eang, 2009) in that they have different operating schedules for different functional facilities (Deng & Burnett, 2000). Venter and

Cloete (2007) have also found that there are only a few similarities between hotels and other commercial buildings. Hotel development has some unique characteristics and would therefore require management expertise of a specific nature. They further stated that a combination of extreme uncertainty, an extensive and ever-shifting array of market segments and high expectations of the parties concerned frequently make hotel development more exciting and challenging than any other kind of real estate development (Venter & Cloete, 2007). Therefore, it is evident that hotel construction involves very complex and high risk projects often requiring huge amounts of time, energy and capital investment. Moreover, Venter and Cloete (2007) have suggested that the physical implementation of such a project requires good co-ordination among architects, engineers and contractors and its success would depend on a combination of factors such as marketing, economics, location, enterprise, professionalism of the project team and planning and design.

Present demand for hotel construction in Sri Lanka

In a recent survey, International Finance Corporation (IFC, 2013) has mapped all types of existing hotels and those that are currently under construction in Sri Lanka. Figure 2 shows the number of existing hotels and the number under construction.

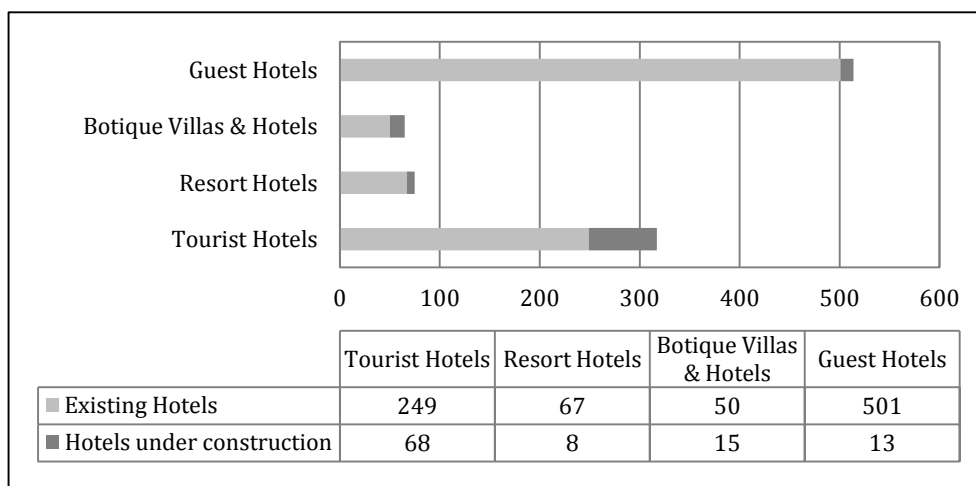


Figure 2: Existing and under construction hotels in Sri Lanka
 (Source: International Finance Corporation [IFC], 2013)

From Figure 2, it is evident that accommodation facilities for domestic tourists need to be increased significantly although the ongoing projects in the hotel sector can be expected to cater to the anticipated increase in the tourist arrivals (CBSL, 2013) from overseas. Timely completion of these projects giving due consideration for costs and quality of work would be vital.

Suitability of construction management to hotels

Several reviewed literature has indicated some of the key features of the CM procurement method. Certain characteristics unique to hotel building construction have been identified as procurement selection factors. Appropriate correlation between these factors will indicate CM as a procurement method suitable for the construction of hotel buildings.

METHODOLOGY

This research is designed as a survey study to analyse the suitability of CM as a procurement method for the construction of hotel buildings in Sri Lanka. A mixed approach is supplemented with both a qualitative and a quantitative analysis of the survey data. The foremost two objectives were merely attained with qualitative analysis of interviews. Since the final objective targeted to identify the suitability of CM as a procurement method for construction of hotel buildings in a quantitative manner, the outcome of research technique should be easy to analyse and quantify. Therefore, an appropriate questionnaire survey with close ended questions was prepared by merging the qualitative results of the semi-structured interviews. Figure 3 shows the techniques of survey approach of this study.

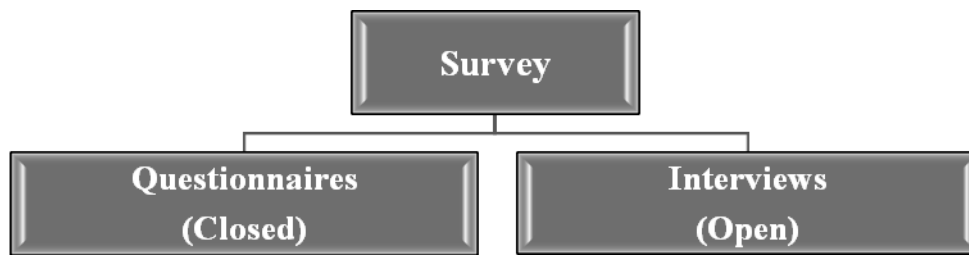


Figure 3: Techniques of survey approach

(Source: Kumaresan, 2010)

Interviews

The key objectives of the interviews were to identify different types of procurement methods available in the Construction Industry and also the unique characteristics of hotel building construction that can be considered as procurement selection factors. Therefore in order to identify additional factors to those provided in literature review, semi-structured interviews were conducted among three experts who were purposely selected from the Construction Industry each of whom has had more than 20 years of experience working in well-reputed organizations. Interview data was analysed using code based content analysis.

Questionnaire survey

The questionnaire survey was aimed at accomplishing the primary objective of the research which is to analyse the suitability of CM as a procurement method for the construction of hotel buildings in Sri Lanka. Thus, as a quantitative component of the study, the detailed questionnaire survey was conducted among purposely selected professionals in the Construction Industry who are having experience and knowledge in the area of both hotel buildings construction and CM procurement method. The respondents came from different types of organisations viz., clients, consultants and contractors and had varying educational and professional qualifications and experience. All had a minimum of five years’ experience in the Construction Industry. There were fifty (50) responses to the eighty five (85) questionnaires that were distributed among the respondents which resulted in a rate of response of 58.82%. Multi-attribute analytical technique with the aid of SPSS statistical software was used to analyse the respondents’ rankings to CM as a procurement method that can be adopted in the construction of hotel buildings.

TYPES OF PROCUREMENT METHODS AVAILABLE IN THE CONSTRUCTION INDUSTRY

The available types of procurement methods were identified through literature review and through the use of semi-structured interviews and these methods were modified to suit the conditions in Sri Lanka. The procurement systems presently practiced can be categorized into four comprehensive categories, i.e. Separated Systems, Integrated Systems, Management Oriented Systems; and Collaborative Systems. In Table 2, procurement methods identified through interviews are highlighted in **bold** text. In Separated Procurement Systems, ‘Provisional Quantities’ and ‘Variation Provisions’ can be treated as alternative procurement methods. Furthermore, ‘Development Agreement’ is a flexible means of implementing a property development project. Public-Private Partnerships (PPP) and Production Sharing Agreements (PSA) are two alternatives under Concession Contracts in Integrated Procurement Systems. Early Contractor Involvement (ECI) is another procurement method coming under the category of Collaborative Procurement Systems.

Table 2: Identified alternative construction procurement methods

<i>Separated Procurement Systems</i>	
<ul style="list-style-type: none"> • Lump sum • Measure and pay (Re-measurement) • Prime cost (Cost reimbursement) • Schedule of rates 	<ul style="list-style-type: none"> • Provisional quantities • Variation provisions • Development agreement
<i>Integrated procurement systems</i>	
<ul style="list-style-type: none"> • Design and build • Novated design and build • Turnkey 	<ul style="list-style-type: none"> • Concession contracts <ul style="list-style-type: none"> - Private finance initiatives (PFI) [BO; BOO; BOT & BOOT] - Production sharing agreement (PSA) - Public-private partnerships (PPP) [DBOM; DBM; DBF & DBFM] • Package deal • Long term maintenance and infrastructure services contracts

<i>Collaborative Procurement Systems</i>	
<ul style="list-style-type: none"> • Join ventures • Partnering • Alliancing (Single TOC) 	<ul style="list-style-type: none"> • Voluntary arrangements • New engineering • Early Contractor Involvement (ECI)
<i>Management Oriented Procurement Systems</i>	
<ul style="list-style-type: none"> • Construction management • Management contracting 	<ul style="list-style-type: none"> • Design and Manage

UNIQUE CHARACTERISTICS OF HOTEL BUILDING CONSTRUCTION THAT CAN BE CONSIDERED AS PROCUREMENT SELECTION FACTORS

In Section 2.3.1, the unique characteristics of hotel building construction have been identified through literature review. Several other characteristics unique to hotel building construction have been identified as procurement selection factors through semi-structured interviews (Refer the second column in each of the Tables 3, 4 and 5). In each of the Tables given in Sections 6.1, 6.2 and 6.3, the characteristics that were identified through interviews are highlighted in bold text. Some characteristics have been identified as clients' requirement related procurement selection factors, viz., price competition (prequalification, tendering cost and value for money), fastness of response to clients' new requirements (variations and extra work), reliability and innovativeness in the design and configuration of facilities (workmanship, functionality, efficiency and comfort), sustainability, payment method, usage of long lead items and time constraints were identified as project related procurement selection factors. The influence of foreign countries and the economic and political conditions of the country were identified as external environment related procurement selection factors. The characteristics unique to hotel building construction that come under each of the three types of procurement selection factors individually contribute to the selection of the most suitable procurement method. Therefore, these procurement selection factors based on the characteristics that are unique to hotel building construction can be used as a basis to analyse the suitability of CM as a procurement method for hotel building construction in Sri Lanka.

SUITABILITY OF CM AS A PROCUREMENT METHOD FOR THE CONSTRUCTION OF HOTEL BUILDINGS

This Section attempts to accomplish through a questionnaire survey the key objective of the research, which is to analyse the suitability of CM as a procurement method for the construction of hotel buildings. The respondents were requested to rank the suitability of CM as a procurement method for a given scenario in hotel building construction based on a five point Likert scale. Finally, the Mean Rating Value (MR) was used to analyse the level of suitability of CM towards meeting a given characteristic of hotel construction and the Overall Suitability Score (OSS) has been used to indicate the overall suitability of CM as a procurement method for the construction of hotel buildings. Suitability was analysed under three categories viz., 1. Clients' requirement related 2. Project related and 3. External environment related after which the overall suitability was analysed.

Suitability of CM to hotel construction in relation to clients' requirement related procurement selection factors

Throughout the interviews, eleven (11) clients' requirement related procurement selection factors were identified in relation to hotel building construction and in the questionnaire survey respondents were requested to rank the suitability of CM as a procurement method against each selection factor.

Table 3 given below presents these procurement selection factors in the order of their significance based on the mean value of the ranks given by the respondents.

The results of the survey clearly indicate that the 'Aesthetics of the building' (C6) is collectively identified as the most significant clients' requirement related procurement selection factor. This was evident from its Mean Rating (MR) value of 4.43. Moreover, 'Reliable and innovative design' (C10) was identified as the second most significant clients' requirement related procurement selection factor in assessing the suitability level of CM to hotel buildings construction. It had a Mean Rating (MR) value of 4.34. Each of the clients' requirement related factors C11, C1, C9, C7 and C4 has obtained a Mean Rating (MR) value of more than 4.00 in the suitability ranking of CM to hotel building construction. Therefore, all these clients' requirement related procurement selection factors indicate CM as a 'highly suitable' procurement method for the construction of hotel buildings in Sri Lanka. Each of the clients' requirement related factors C2, C3 and C5 has obtained a Mean Rating (MR) value of more than 3.00 in the suitability ranking of CM to hotel building construction and all these clients' requirement related procurement selection factors indicate CM as a "moderately suitable" procurement method for the construction of hotel buildings in Sri Lanka.

Table 3: Suitability of CM to hotel construction in relation to clients' requirement related procurement selection factors

NO	Client related procurement selection factors	Suitability level					MR	RII	CSS	Rank
		<i>VHS</i> 5	<i>HS</i> 4	<i>MS</i> 3	<i>SS</i> 2	<i>NS</i> 1				
C6	Aesthetic of building	53%	38%	9%	0%	0%	4.43	0.887	0.357	1
C10	Reliable & innovative design	51%	32%	17%	0%	0%	4.34	0.781	0.315	2
C11	Configuration of facilities (Workmanship, Functionality, Efficiency & Comfort)	38%	55%	2%	6%	0%	4.25	0.800	0.309	3
C1	Cost related short term objectives (Capital cost & Completion within budget)	43%	32%	15%	9%	0%	4.09	0.819	0.305	4
C9	Quick response to clients new requirements (Variations & Extra work)	34%	47%	9%	9%	0%	4.06	0.811	0.299	5
C7	Team performance	36%	36%	23%	6%	0%	4.02	0.804	0.294	6
C4	Time related factors (Planning, Designing, Tendering, Evaluation, Construction time, Early start, Speed of construction)	42%	26%	23%	9%	0%	4.00	0.849	0.309	7
C2	Cost related long term objectives (Maintenance cost & Operational cost)	28%	40%	26%	6%	0%	3.91	0.868	0.309	8
C3	Financial risk factors	34%	43%	8%	9%	6%	3.91	0.781	0.277	8
C5	Stage completion	21%	25%	21%	30%	4%	3.28	0.558	0.166	10
C8	Price competition (Prequalification and tendering cost & Value for money)	13%	13%	32%	23%	19%	2.79	0.657	0.167	11
Overall suitability score									3.107	
Very Highly Suitable (VHS) = 5, Highly Suitable (HS) = 4, Moderately Suitable (MS) = 3, Somewhat Suitable (SS) = 2, Not Suitable (NS) = 1										

Suitability of CM to hotel construction in relation to project related procurement selection factors

There were nine (9) project related procurement selection factors that were considered in relation to hotel building construction. Table 4 below indicates these project related procurement selection factors in the order of their significance which is based on the mean value of the ranks given to them by the respondents.

Table 4: Suitability of CM to hotel construction in relation to project related procurement selection factors

NO	Project related procurement selection factors	Suitability level					MR	RII	CSS	Rank
		<i>VHS</i> 5	<i>HS</i> 4	<i>MS</i> 3	<i>SS</i> 2	<i>NS</i> 1				
P2	Project complexity (Cost, Technique & construction method)	66%	26%	8%	0%	0%	4.58	0.917	0.467	1
P9	Usage of long lead items	47%	47%	6%	0%	0%	4.42	0.883	0.433	2
P6	Time constrains	49%	25%	26%	0%	0%	4.23	0.845	0.397	3
P4	Project site location	51%	21%	9%	19%	0%	4.04	0.736	0.330	4
P1	Project physical characteristics (Type, Size)	42%	19%	17%	19%	4%	3.75	0.751	0.313	5
P5	Site risk factors	17%	42%	34%	8%	0%	3.68	0.808	0.330	6
P8	Sustainability	19%	36%	32%	13%	0%	3.60	0.721	0.289	7
P7	Payment method	25%	30%	23%	23%	0%	3.57	0.672	0.267	8
P3	Project funding method	23%	23%	28%	21%	6%	3.36	0.713	0.266	9
Overall suitability score									3.092	
Very Highly Suitable (VHS) = 5, Highly Suitable (HS) = 4, Moderately Suitable (MS) = 3, Somewhat Suitable (SS) = 2, Not Suitable (NS) = 1										

The results of the survey clearly indicate that 'Project Complexity (Cost, Technique and construction method)' (P2) is the most significant project related procurement selection factor having a Mean Rating (MR) value of 4.58. The 'Usage of long lead items'(P9) which was placed as the second most significant project related procurement selection factor had a Mean Rating (MR) value of 4.42. Each of the project related factors P6 and P4 has obtained a Mean Rating (MR) value of more than 4.00. Thus, these project related procurement selection factors indicate CM as a 'highly suitable' procurement method for the construction of hotel buildings in Sri Lanka. Each of the project related factors P1, P5,

P8, P7 and P3 has obtained a Mean Rating (MR) value of more than 3.00 and all these project related procurement selection factors also indicate CM as a ‘moderately suitable’ procurement method for the construction of hotel buildings in Sri Lanka.

Suitability of CM to hotel construction in relation to external environment related procurement selection factors

There were six (6) procurement selection factors identified under the category of external environment related procurement selection factors. Table 5 below indicates these six procurement selection factors in the order of their significance based on the mean value of the ranks given to them by the respondents.

Table 5: Suitability of CM to hotel construction in relation to external environment related procurement selection factors

NO	External environment related procurement selection factors	Suitability level					M R	RII	CSS	Rank
		VHS 5	HS 4	MS 3	SS 2	NS 1				
E2	Experienced, Educated contractors availability	43%	43%	13%	0%	0%	4.30	0.860	0.617	1
E3	Material availability	38%	38%	17%	8%	0%	4.06	0.811	0.549	2
E1	Government policy	21%	40%	15%	25%	0%	3.57	0.702	0.418	3
E4	External risk factors (Industrial actions, Environmental issues, disasters & etc.)	23%	26%	30%	21%	0%	3.51	0.713	0.417	4
E6	Influence of Foreign countries	17%	21%	47%	15%	0%	3.40	0.653	0.370	5
E5	Economic & political condition of country	21%	17%	30%	32%	0%	3.26	0.679	0.369	6
Overall suitability score									2.740	
Very Highly Suitable (VHS) = 5, Highly Suitable (HS) = 4, Moderately Suitable (MS) = 3, Somewhat Suitable (SS) = 2, Not Suitable (NS) = 1										

The results of the survey reveal that ‘Experienced, Educated Contractors availability’ (E2) was perceived as the most significant external environment related procurement selection factor obtaining a Mean Rating (MR) value of 4.30. Meanwhile, ‘Material availability’(E3) placed as the second most significant external environment related procurement selection factor had a Mean Rating (MR) value of 4.06. Each of the external environment related factors E1, E4, E6, and E5 has obtained a Mean Rating (MR) value of more than 3. Thus all these project related procurement selection factors indicate CM as a ‘moderately suitable’ procurement method for the construction of hotel buildings in Sri Lanka.

Overall suitability of CM procurement method for the construction of hotel buildings

The survey analysis reveals that all three procurement selection criteria (clients’ requirement related, project related and external environment related) indicate CM as a ‘moderately suitable’ procurement method for the construction of hotel buildings in Sri Lanka.

Table 6: Suitability of CM procurement method for construction of hotel buildings in relation to procurement selection factors

Suitability level	Project procurement selection factors		
	<i>Clients’ requirement related</i>	<i>Project related</i>	<i>External environment related</i>
Very Highly Suitable	N/A	N/A	N/A
Highly Suitable	C6, C10, C11, C1, C9, C7, C4	P2, P9, P6, P4	E2, E3
Moderately Suitable	C2, C3, C5	P1, P5, P8, P7, P3	E1, E4, E6, E5
Somewhat Suitable	C8	N/A	N/A
Not Suitable	N/A	N/A	N/A
Overall suitability score (OSS)	3.107	3.092	2.740
OSS value: < 1.51: Not suitable, 1.51 – 2.49: Somewhat suitable, 2.50 – 3.49: Moderately suitable, 3.50 – 4.49: Highly suitable, > 4.49: Very highly suitable			

This was evident from Table 6 which illustrates an Overall Suitability Score (OSS) of 3.107 to the CM procurement method in relation to clients' requirement related, an Overall Suitability Score (OSS) of 3.092 in relation to project related and an Overall Suitability Score (OSS) of 2.740 in relation to external environment related procurement selection factors.

Table 6 provides a summary of the suitability level of the CM procurement method for the construction of hotel buildings based on procurement selection factors related to clients' expectations, project requirements and environmental aspects by considering the mean rating (MR) value obtained by each factor.

CONCLUSIONS AND RECOMMENDATIONS

With the increasing pace of economic development taking place in the country, more and more hotels are being constructed in Sri Lanka. In order to achieve the desired objectives of economic development with a highly efficient Construction Industry, it is necessary to consider different options available for procurement of hotel buildings. This study therefore aimed analysing the suitability of CM as a procurement method for the construction of hotels and at the same time at identifying different types of procurement methods practiced in the construction of hotel buildings and the characteristics that are unique to such methods.

There are two major procurement systems practiced in the Construction Industry, viz., the traditional system and the non-traditional system. A traditional system is separated procurement system and a non-traditional system has integrated, collaborative and management oriented procurement systems coming under it. There were eleven (11) clients' requirement related, nine (9) project related and six (6) external environment related characteristics that were identified as procurement selection factors unique to hotel building construction. The results of the analysed questionnaire survey indicated that CM satisfies all three procurement selection factors with an Overall Suitability Scores (OSS) of 3.109, 3.092 and 2.740 respectively. Therefore, all these three procurement selection factors have proved the CM to be a 'moderately suitable' procurement method for the construction of hotel buildings in Sri Lanka. According to research findings, it is revealed that the current hotel building capacity in the country needs to be increased in a very short time span if the increasing number of tourist arrivals is to be accommodated. This is however considered to be impracticable given the long lead time that hotel development requires and the poor performance of the Construction Industry. Furthermore, it has to be noted that the type of procurement method chosen significantly affects the performance of the Construction Industry. Therefore, it is strongly recommended that those who intend to invest in the hotel industry and those who practice in the Construction Industry select a form of CM that is suitable to their particular project. Finally, it has to be mentioned that although in our country, there are organizations that undertake contracts or provide consultancy services or even function as clients there is not a single organization that undertakes. Therefore, it is recommended that the Construction Industry seriously considers establishing organizations to promote CM in the Construction Industry to make CM popular within the Industry as an effective procurement method suitable for that industry.

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Competencies Expected of Graduate Quantity Surveyors by the Sri Lankan Construction Industry

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Abstract

Quantity surveying is one of the prominent professions in the construction industry. With the increasing complexity in construction projects, competencies of QSs have become utmost significant. Moreover, new opportunities of the quantity surveying profession reinforce the need to upgrade the competencies of graduates. However, the quantity surveying education system has not attempted to cater the needs of the industry, thus lagging behind the perceived level of achievement. Hence, this study aims at identifying the gap in competencies required by professional organisations and those possessed by graduate QSs.

This study employed a hybrid survey approach. Firstly, external and internal desk studies were conducted to identify the competencies required by professional bodies and the competencies possessed by graduate QSs respectively, which was then analysed using the thematic analysis technique. Secondly, three expert interviews were conducted to validate the findings of the desk reviews. Finally, Bloom's Taxonomy was used to identify the level of competencies possessed by graduate QSs. The analysed data revealed that the graduates possess all competencies required by the professional organisations, except Capital allowance, Corporate recovery and insolvency and Special assessment. Further, they possess Building surveying, Property development and Surveying and levelling, beyond the requirements of the professional organisations.

Keywords: *Competencies, Construction Industry, Graduate Quantity Surveyors.*

1.0 Introduction

Quantity surveying, being an eminent profession in the construction industry, adds value to the contractual and financial management of construction projects in all its stages (Dada & Jagboro, 2012). Today, QSs have slew of roles to play, both within and outside the construction industry. This profession requires indispensable competencies to apply their knowledge to a wide range of contexts. Competencies of QSs have been listed out by professional bodies namely Institute of Quantity Surveyors in Sri Lanka (IQSSL), Royal Institute of Chartered Surveyors (RICS), Australian Institute of Quantity Surveyors (AIQS) and Pacific Association of Quantity Surveyors (PAQS). They ensure that QS practitioners are dedicated to maintaining the highest standards of professional excellence.

This emerging profession has drawn in the attention of many institutions in the country to develop number of quantity surveying degree programs, owing to its increased demand. Academic institutions aspire to yield QSs who are versatile graduates; whereas the professional associations seek to help the graduates accomplish the competencies adumbrated by them and thus attain full professional status. On the contrary, construction industry anticipates forthwith contribution of graduate QSs to routine business functions as well as to its growth. However, QS education systems have not discerned these multidimensional needs and thus the graduate QSs are often reckoned as not being up to the standard expected by the industry (Perera, Pearson, Zhou & Ekundayo, 2011). Though Sri Lankan QSs are well recognised, still there are lashings of competencies absent in them. Further, with the increased needs and complications in the industry, the role of QSs has considerably changed and requires variety of new skills to perform the job successfully (Niroshan, 2012). Therefore, this research focuses on identifying the lacking competencies with the intent of bringing them to the attention of future QSs. Hence, the objectives of this paper are,

1. To ascertain the core competencies required from graduate QSs.
2. To determine the competencies possessed by graduate QSs.
3. To determine the level of competencies possessed by graduate QSs.
4. To identify the substandard competencies of graduate QSs.

This research is limited to the competencies that can be gained from the graduate course of study which is accredited by IQSSL, RICS, AIQS and PAQS, and does not conceive competencies that are attained from work experience.

This paper begins in the following sections with a review of literature on quantity surveying profession. The next section presents the research methodology followed by findings of the study, and finally presents conclusions and recommendations.

2.0 Literature synthesis

1.1 2.1 *What is quantity surveying?*

Quantity surveying has been defined considering different aspects. Financial management aspect has been the root of quantity surveying and still it is the expectation of employing a QS (Fanous & Mullins, 2012). Ashworth, Hogg and Higgs (2013) have defined QS as a professional who “ensures that the resources of the construction industry are utilised to the best advantages of society by providing, inter alia, the financial management for projects and cost consultancy services to the client and designer during the whole construction process” (p.1). Badu and Amoah (2004) defined quantity surveying as the profession having the ability to analyse both cost components and practical physical construction works of a project in a successful way so as to be able to apply the results of his analysis in solving problems peculiar to each project. Further, Brandon (1992) defined quantity surveying as an amalgam of several other disciplines within a unique context of the built environment. With these definitions, quantity surveying can be portrayed as a fusion of several fields such as economics, law, accountancy, management, measurement, information technology and construction technology that acts amongst all sectors of economy. However, the ultimate objective of the profession is to enable the client derive optimum value for the money spent. For that to be attained, QSs have to perform scads of roles and duties, which are addressed in the following section.

1.2 2.2 *Roles and duties of quantity surveyors*

QSs engage in construction projects from initiation to closeout. With the maturation of the profession, its roles and duties have substantially changed. Today, QSs have to perform traditional as well as contemporary roles. Traditionally, they were working only as Consultant's, Contractor's and Client's QSs. At present, they have imbued into other industries like insurance, financial, manufacturing, taxation, valuation (Hemajith *et al.*, 2007), petro chemical, mining, aeronautical, shipping and transport industries (Smith, 2004), which are new-fangled directions of the profession. Duties can be esteemed in different facets. Jeyamathan (2005) has pertained the duties of QSs into their roles and phases of contract. According to Ashworth and Willis (1998), duties of QSs can be considered with the progress of a project, which commences at initial stage of construction and continues throughout the project. Identification of duties by Ashworth and Willis (1998) has addressed the traditional and some of the non-traditional duties of quantity surveyors. Moreover, Fanous and Mullins (2012) have distinguished the duties of QS and categorised them as traditional duties, evolved duties and emerging duties. However, Fanous and Mullins (2012) have not regarded risk management, quality management, feasibility study, taxation advice, expert witness/appraisal, value management (Smith, 2004), premises audit and post occupancy evaluation (Chong *et al.*, 2012) in their itemisation of emerging duties. If they are incorporated into the above classification by Fanous and Mullins (2012), it will give a thorough picture of duties of QSs.

2.3 *Competencies of quantity surveyors*

Competency is a description of an action, behaviour or outcome which a person should be able to demonstrate, or the ability to transfer skills and knowledge to new situations within the occupational area (Holmes & Joyce, 1993). Any professional should possess an extensive range of competencies in order for him to effectively handle his work in the relevant discipline. Quantity surveying, being a profession perpetually faced up with challenges and new opportunities thereby calls for distinctive competencies to excel in current and future practices. Graduate QSs acquire competencies from formal quantity surveying didactics at the university and the workplace training (Perera, Pearson, Robson, & Ekundayo, 2011). According to RICS and Male (as cited in Nkado & Meyer, 2001), measurement and valuation are the distinctive competencies which are crucial for proper cost management of construction projects. However, Leveson (as cited in Nkado & Meyer, 2001) stated that competencies of QSs reside in financial and contractual control of the project and proposed to develop their interpersonal skills. Nkado and Meyer (2001) identified the competencies of QS as relationship, built environment objectives, technical skills and property economics. Yet, none of the findings emphasise which competencies are essential for exceptional performance of QSs.

2.4 Quantity surveying in Sri Lanka

Rapid changes in construction industry at present call for well qualified QSs to meet the increasing demand and needs of the industry. Sri Lankan construction industry is yet committed with traditional quantity surveying practices (Fanous & Mullins, 2012). They rely on simple IT applications to accomplish their day-to-day routine tasks. Yet, they have not embarked into the modern construction era of the cybernated age.

Expectations of the construction industry and quantity surveying education need to be conceived together for successful carry-over of graduates to the industry (Perera *et al.*, 2011). According to Mahbub (as cited in Zakaria, Munaim & Khan, 2006), present industry expects graduates to possess not only subject knowledge but, to have communication skills, good command in English, commitment, physical and mental endurance, IT knowledge, ability to learn, creativity, leadership, negotiation and self-motivation, which makes them employable. According to Zakaria *et al.*, quantity surveying education offered by institutes is not completely satisfying the needs of the present industry. It is affirmed in a study by Perera *et al.* (2011). Thus, improving competencies of graduate QSs is of the essence.

1.3 2.4.1 Threats confronted by QS profession

Accompanying the maturation of the profession, it calls for development of competencies of graduates so that they can keep step with the potential challenges in future construction industry. At present, major threat to the profession is the increasing discontent of the industry regarding the competencies of graduates. Industry's prolonged concern is regarding the mismatch of learning outcome and industry requirements. They view graduates as lacking knowledge on construction technology and thereby having no apprehension of on-site conditions (Perera *et al.*, 2010). In addition, less precedence is given to management oriented competencies in current practice of profession, whereas this will gain significance in future according to the study carried out by Nkado (2000). Therefore, quantity surveying education system must conceive this deficiency in managerial skills and proactively audit the curriculum.

Further, graduate QSs excel in theoretical knowledge. However, they lack in soft skills and attitudes (Zakaria *et al.*, 2006). Another threat is the involvement of non-construction personnel in providing quantity surveying services (Chandrasiri, 2010). As identified by Chong *et al.* (2012), clients looking for new ways to manage contracts further fortify this threat to the profession. Since IT is the paradigm of today's industry, the emerging developments in technology can automate almost all the roles of QSs. Though not yet implemented in Sri Lanka, BIM is the most raging IT solution that would entirely change the role of all professionals. Thus, it challenges the existence of the profession. To overcome this, QSs need to enhance their skills on QS specific BIM technology (Nagalingam *et al.*, 2013). Furthermore, with the increased number of institutions providing quantity surveying education, there are surplus graduates in the market. Moreover, involvement of foreign professionals in local project is an added reason for lowering opportunities for local QSs. Fewer opportunities within the country are a threat to the profession (Chandrasiri, 2010). All these menaces have placed a challenge on the profession. To confront these challenges and enhance their professionalism and status, they are obligatorily expected to fortify the essential competencies.

2.5 Importance of identifying the competencies expected by construction industry from graduate quantity surveyors

Graduate QSs acquire competencies from formal university education and workplace training. Regulating associations of the profession have adumbrated guidelines regarding competencies to be attained by graduates through their education at the university. However, there is no benchmark as to the level of competencies to be achieved by them. Owing to absence of competency benchmark, there is a mismatch between the expectations of graduate competencies by construction industry and the competencies possessed by graduate QSs. This has led to the industry being dissatisfied of the competencies of graduate QSs (Perera *et al.*, 2011).

On the other hand, competencies to be accomplished by graduate QSs are pulled in different directions by the industry and the education system. Industry expects graduates to directly involve in all quantity surveying functions together with contributing to their growth. It anticipates graduates to possess theoretical knowledge, technical know-how as well as the essential soft skills as they step in to the industry. It does not recognise the potentiality of graduates to develop their professional skills once they are employed. On the contrary, the education systems focus on bringing forth versatile graduates who have the foundation knowledge in all aspects of the profession plus the capability for further development in future. As it does not consider the opposing needs of the industry, graduate QSs are lacking in certain competencies which are expected by the construction industry (Perera *et al.*, 2010).

At the same time, there is only limited number of studies heretofore, concerning the competencies of graduate QSs, as shown in table 2.1.

Table 2.1: Studies related to competencies of graduate QSs

Author	Year	Name of study
Nkado	2000	Competencies of professional QSs for the future career, Competencies of professional QSs in a developing economy, Competencies required by South African QSs
Nkado and Meyer	2001	Competencies of professional QSs: A South African perspective
Shafiei and Said	2008	The Competency Requirements for QSs: Enhancing Continuous Professional Development
Derus, Yunus and Saberi	2009	In Search of Competencies of an Exceptional QS in Public Entity: Building a Theoretical Foundation
Perera, Pearson, Robson and Ekundayo	2011	Alignment of academic and industrial development needs for QSs: the views of industry and academia (UK)
Author	Year	Name of study
Dada and Jagboro	2012	Core Skills Requirement and Competencies Expected of QSs: Perspectives from QSs, Allied Professionals and Clients in Nigeria
Perera, Pearson, Zhou and Ekundayo	2012	Developing a graduate competency mapping benchmark for quantity surveying competencies

However, none of these studies have explored into competency requirements of quantity surveying graduates in Sri Lanka. Hence, there is a deficiency in literature in this regard.

Further, as identified in the aforementioned literature synthesis, future role of QSs will apparently mature from what it is at present. In addition, quantity surveying profession will disseminate into many other industries, without being bounded to construction. All these changes will call for new and diverse skills of graduates to successfully takeover their duties in the future industry. Hence, there is indispensable need for the identification of competencies expected by the industry, with the objective of aligning the industry expectations with competencies possessed by the graduates.

3.0 Research methodology

An extensive literature survey about quantity surveying profession was carried out to emphasise the significance of the research problem. Next step was to execute external desk review with the competency standards established by the professional authorities such as IQSSL, RICS, AIQS and PAQS, which determined the competencies required to be possessed by graduate QSs. Following this, an internal desk review with the QS curriculum being used by a QS degree program accredited by the above professional authorities was done to find the competencies possessed by graduate QSs. Internal and external desk review was conducted using thematic analysis technique. Thematic analysis is considered the most appropriate for any study that seeks to discover using interpretations and it provides a systematic element to data analysis (Alhojailan & Ibrahim, 2012). It is theoretically flexible because thematic analysis can be learned and used without some of the potentially confusing theoretical knowledge that is essential for many other qualitative approaches. Steps involved in carrying out thematic analysis are described in section 4.1.1. Findings of the desk reviews were then validated by three experts, who are a part of quantity surveying course of study that is accredited by IQSSL, RICS, AIQS and PAQS. Following this, the curriculum was analysed by referring to Bloom's Taxonomy, to identify the level of competencies possessed by graduate QSs.

4.0 Data analysis

4.1 External desk review-Identification of competencies required from graduate quantity surveyors

Competencies required from graduate QSs were ascertained by conducting thematic analysis with the Competency standards insinuated by IQSSL, RICS, AIQS and PAQS. Following text gives a brief description of each of the above competency standards.

IQSSL Competencies

IQSSL is the only local professional organisation which has developed a competency standard for QSs. IQSSL competency standard specify the competency areas that are required to be attained by QSs, together with the targeted achievement. It is similar to AIQS competency standard.

RICS Competencies

RICS competencies are sorted into three groups as mandatory, core and optional competencies. Each group is set up based on their prominence to the profession and are outlined at three levels of attainment as given below.

- Level 1 - knowledge and understanding (knowing)
- Level 2 - application of knowledge and understanding (doing)
- Level 3 - reasoned advice and depth of technical knowledge (advising)

AIQS Competencies

According to AIQS (1997), competencies are dissevered into competency units, each of which describes a peculiar element of a QS's role in terms of performance criteria, range indicators and evidence guides.

Competency standard units are categorised into core and specialist units. Core units represent the competencies which should mandatorily be possessed by QSs. Specialist units are functions which can be executed by QSs and many other professionals in the construction industry, but require special noesis beyond what is attained through the quantity surveying degree program.

PAQS Competencies

PAQS competencies are similar to AIQS competency standards except that AIQS competencies are more dilated. PAQS competencies are categorised as core and specialist competencies, each of which is determined in terms of unit of competency, performance criteria, range indicators and evidence guides (PAQS, 2001).

Following steps were followed in conducting thematic analysis. Prior to auctioning thematic analysis, secondary data collected from the above four professional associations were separately tabulated to reduce the complexity.

Step 1

As the first step of thematic analysis, tabulated data was read and re-read several times which lead to data engrossment. Simultaneously, initial ideas were noted down to make the analysis more comfortable.

Step 2

The next step was the initial coding stage where manual coding was done by highlighting the data pertinent to the research question. At this step, similar competencies in all four competency standards were highlighted. Simultaneously, competencies which cannot stand on their own were included under other competencies. For example, Communication skills in RICS competencies were grouped under 'Support competencies'. At the end of this step, coding generated from each competency standards was summarised in a tabulated form, in order to simplify the succeeding step. Repeated patterns in the tabularised summary were given consideration, which is the key for generating themes.

Step 3

Third step is searching for themes, where similar codes identified in the previous step and the data considering the same aspect were aggregated. For example, 'Data management' in RICS competencies, 'Cost information database' in AIQS and PAQS competencies and 'Preparation of cost analysis' in IQSSL competencies were included under the same heading of 'Managing cost data', since they all have the same defined meaning. Table 4.1 shows the combined list of competencies, which was the finding of the external desk review.

Table 4.1: Combined list of IQSSL, RICS, AIQS and PAQS competencies

Competency		Element
1	Cost planning	Analysing alternative design solutions
		Cost controlling during design
		Preparation of cost plans
		Scope audit
2	Cost estimating	Managing cost data
		Preparation of estimates
		Review, evaluation of estimates
3	Strategic planning	Preparation of cost benefit analysis
		Preparation of project brief
		Economic and financial analysis
		Carrying out development appraisal
		Compliance and management studies
4	Contract administration	Progressive financial controlling, reporting and monitoring during construction
		Recommending progress payments/interim valuation
		Managing claims
		Managing variations
		Preparation of correspondences
		Final accounts and reporting
		Managing cash flow during construction
		Administering insurance claims
		Administering, managing of subcontracts and controlling subcontract accounts
Contractual interpretation		
5	Dispute resolution	Resolving disputes
6	Contract documentation	Establishing client requirements
		Measurement
		Preparation of BOQ
7	General procurement advice	Developing resource management plan
		Review procurement systems
8	Tendering process	Review forms of contract, subcontracts
		Managing pre-qualification
		Managing tendering process
		Tender documentation
		Selection of tenderers
9	Government law and regulation	Evaluate, negotiate tenders and award
		Specification writing
10	Construction technology	Knowledge on law, regulations and guidelines related to construction
		Knowledge on construction technologies, process and building materials
		Knowledge of design principals
		Knowledge of principals of construction
11	Resource analysis	Interpretation of drawings, specification and other documents
		Design and installation of services
12	Project management	Analysing and managing resources
		Pre contract planning and programming
		Programme monitoring

13	Risk management	Managing risk
14	Value management	Providing value management services
15	Life cycle cost analysis	Carrying out life cycle cost analysis
16	Budgetary process	Establishing budget
		Coordinating client's cash flow
		Assisting in client's financial control
17	Financial audit	Knowledge on accounting principles, cash flow, cost reconciliation
18	Ethics and professional conduct	Professional practice
19	Feasibility study	Carrying out feasibility study
20	Health and safety	Knowledge on health and safety requirements in construction
21	Capital allowance	Capital allowance
22	Corporate recovery and insolvency	Corporate recovery and insolvency
23	Support competencies	Computer services
		Team working
		Due diligence
		Leadership
		Managing people
		Communication, presentation skills
		Client care
		Economics
24	Sustainability	Knowledge on impact of sustainability in construction
25	Tax depreciation	Tax depreciation
26	Special assessment	Special assessment
27	Quality assurance	Quality assurance
28	Expert witness	Expert witness
29	Business management	Business management
30	Research and development	Research and development

Subsequently, these competencies were grouped under six themes, which were generated by referring to the classifications developed by several scholars who involved in similar studies. Niroshan (2012), Perera (2006) and Willis and Ashworth (1987) grouped the competencies of Qs under four categories namely, Construction Economics, Construction Management, Construction Law and Construction Technology. Further, Perera (2006) emphasised that Information Technology and Business Administration should be included under the above classification. Hence, 'Construction Economics', 'Construction Technology', 'Construction Management' 'Construction Law' 'Construction Information Technology' and 'Business Administration' were selected as the themes under this research.

Step 4

Following this, the above six themes were refined at two levels; primarily with the coded data to ensure they form a consistent pattern, secondly once a coherent pattern was formed the themes were matched against the data set as a whole. This guaranteed that the themes accurately reflect what was evident in the data set as a whole (Braun & Clarke, 2006). In addition, further coding was done at this stage to ensure no codes were missed during previous stages.

Step 5

Next step is defining and designating themes where the essence of each theme was identified as represented in figure 4.1.

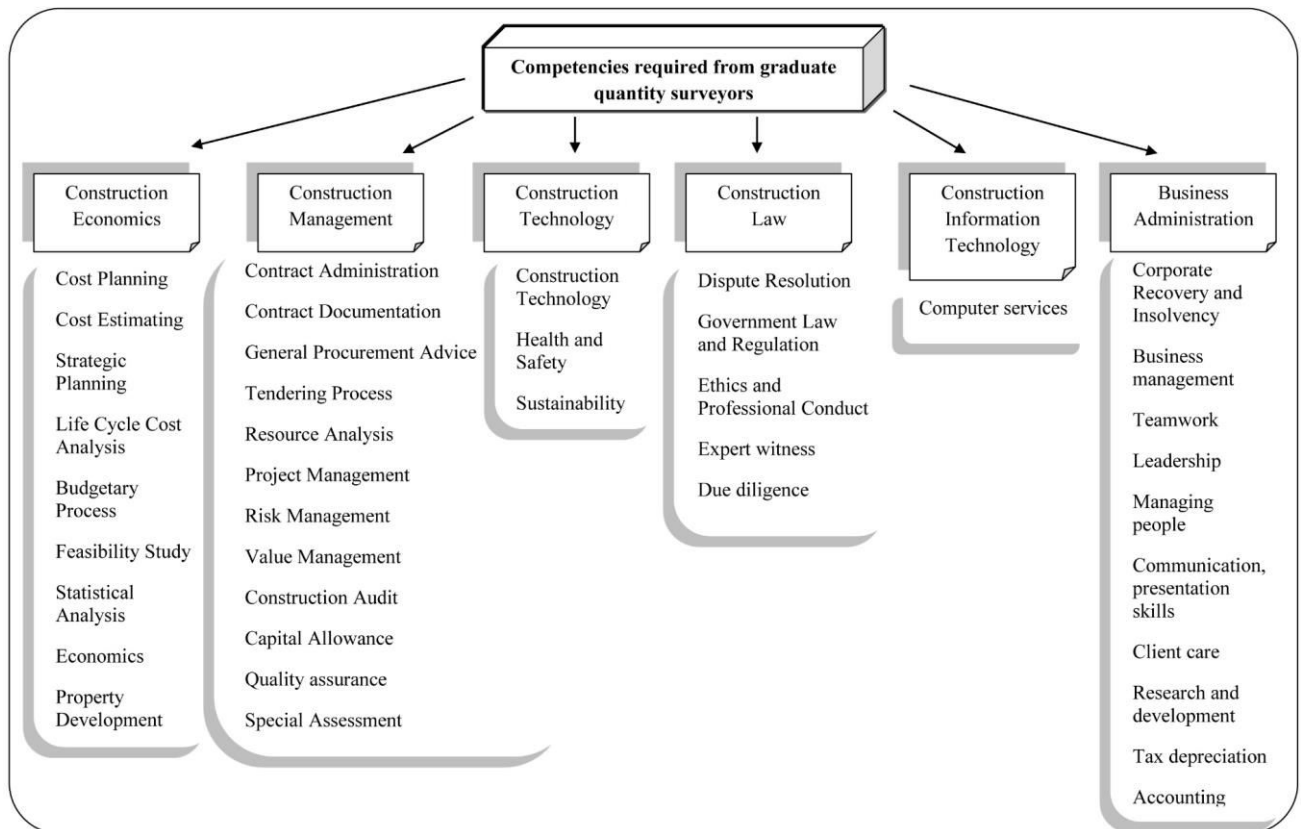


Figure 4.1: Competencies Required from Graduate Quantity Surveyors (Findings of External Desk Review)

Each of the above themes can be defined as shown in figure 4.2:

Construction Economics

- The application of economic principles to construction industry with the aim of economising the construction process from inception through completion, for the entire life of the building. It involves advising the client regarding the best ways to achieve value for money

Construction Technology

- The branch of knowledge pertaining to construction processes, construction materials, plant and equipments and construction technology together with the relevant health and safety requisites, related to building and civil engineering construction

Construction Management

- The overall planning coordinating, managing and execution of construction projects, from inception to completion, to maximize efficiency. Construction management is focused on managing time, cost and quality of construction projects

Construction Law

- The consideration on different aims of the law to the context of the construction industry, yet it is not a discrete branch of law.

Construction Information Technology

- The use of computers and telecommunication systems for creating, storing, retrieving, and transmitting information, to make the QS tasks simpler

Business Administration

- The managing of business using the principles and application of economics, marketing and planning

Figure 4.2: Definitions of themes

Combined list of competencies prepared under external desk review (Refer table 4.1) consists of 30 competencies, each of which includes number of competency elements. Each competency element incorporates its entire process from the beginning to the end. For example, 'Managing variations' covers all activities involved with it, such as requesting for proposal, evaluating the variation, obtaining approvals, determination and issuing variation orders. In addition, this list consists of both core and specialised competencies that are required from Qs. Thus, it cannot be expected that a QS should mandatorily possess all of the competencies mentioned in table 4.1. Hence, the above combined list consists of some competencies that are seldom exercised by Qs, for example, Capital allowance, Corporate recovery and insolvency, Special assessment and Tax depreciation. Further, it comprises of competencies that does not form the primary chore of Qs, but essential for the successful execution of their duties. The competency group identified as 'Support competencies' is composed of such competencies. For example, communication skills, client care, computer services, team working, due diligence and leadership. The remaining competencies forms the principal branches of knowledge required from Qs.

Classification of competencies under the themes, as shown in figure 4.1, demonstrates a broader picture of the competency requirement. According to it, competency of Construction economics and Construction management are the subject areas extensively expected from Qs. In addition, Business administration also gains prominence due to the classification of support competencies under it. Further, the field of Construction technology and Construction information technology proves its grandness by being identified as separate themes.

4.2 Internal desk review - Identification of competencies possessed by graduate quantity surveyors

Competencies possessed by graduate Qs were identified through reviewing the curriculum used by a quantity surveying degree program accredited by IQSSL, RICS, AIQS and PAQS. This was also attained with the use of thematic analysis which includes five steps similar to the process described in section 4.1. Learning outcomes in the curriculum were classified under the competency list formed under external desk review. Additional competencies that were not identified in desk review I, yet attained through the quantity surveying degree program were also named during the process. Building surveying, Surveying and levelling and Property development were such competencies. Though these three competencies were not required by the professional bodies from graduate quantity surveyors, they are addressed in the degree program, at a basic level. Figure 4.3 represents the competencies attained through the quantity surveying degree program as classified under the previously generated themes.

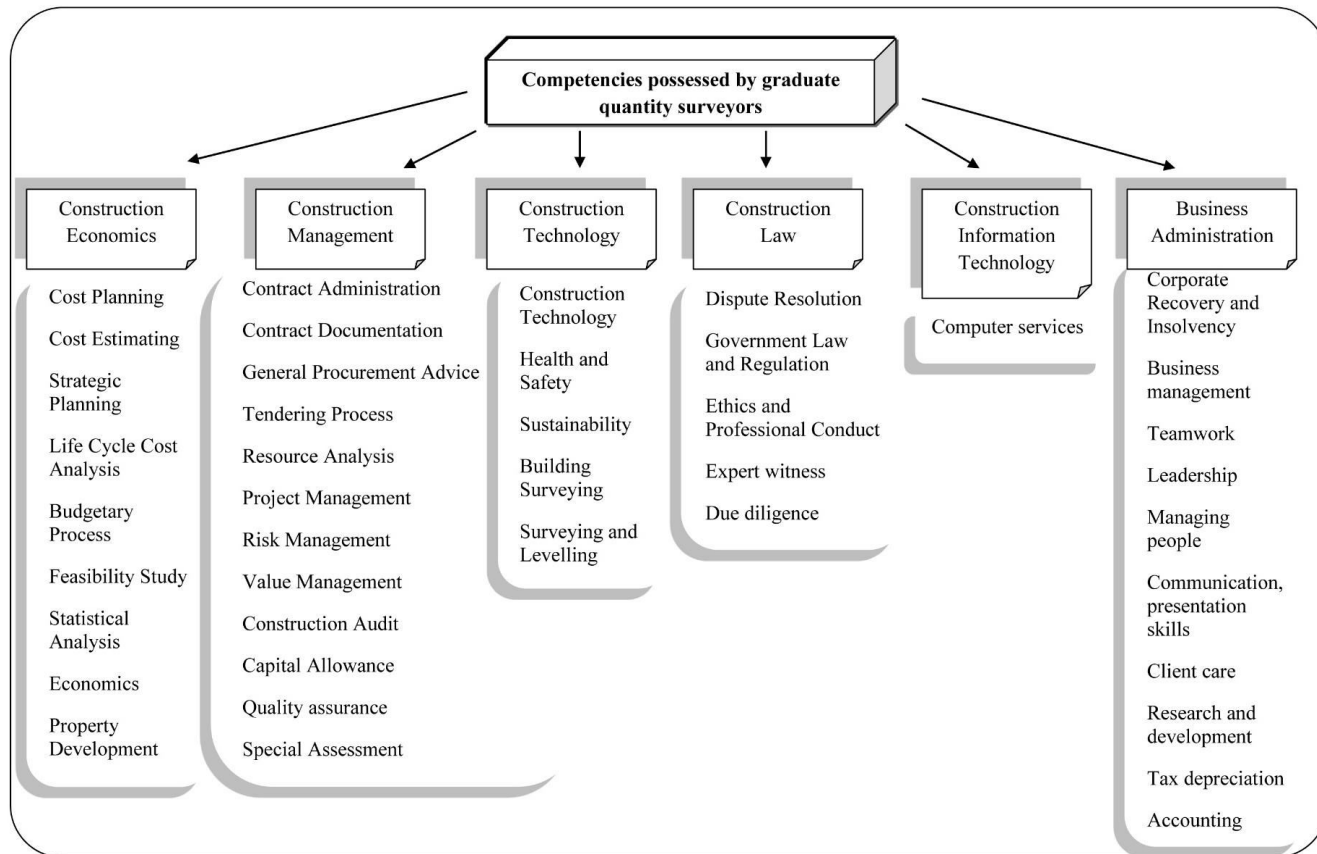


Figure 4.3: Findings of Internal Desk Review

4.3 Expert validation

The validated outcome of the findings of internal desk and external desk review is subjected to minor changes after conducting interviews with three experts in the academia. They are qualified in the area of this research academically as well as professionally. Table 4.2 provides the details of experts who involved in validating the findings.

Table 4.2: Details of Experts

	Designation	Years of experience
1	Senior Lecturer	21
2	Senior Lecturer	17
3	Senior Lecturer	13

Firstly, the proposed changes for the findings of external desk review disclosed the importance of identifying Financial auditing and Technical auditing separately rather incorporating both under the competency Financial auditing. Further, another expert has pointed out the mandatory and optional components of the competency 'Business administration'. Teamwork, Leadership, Managing people, Communication, presentation skills and Client care were identified to be mandatory and the remainder to be optional. Thus, it was expressed that all the competencies in this category cannot be expected to be possessed by all the graduate Qs.

Secondly, the proposed changes for the findings of internal desk review found the principal problem encountered while grouping the learning outcomes in the curriculum. It was the absence of learning outcomes directly explaining some of the competencies. In order to solve this problem, it was proposed by the experts to include such learning outcomes under all competencies which it describes, by replicating under more than one competency. All the changes proposed by the experts were incorporated to make the findings of this paper more sensible in table 4.1, figure 4.1, 4.2, and 4.3.

4.4 Identification of the level of competencies possessed by graduate quantity surveyors

Levels of competencies possessed by graduate Qs were identified by referring to Bloom's Taxonomy, which is a system used to design instruction or learning processes. It addresses three domains of educational activities such as cognitive, affective, and psychomotor. Cognitive domain has been conceived to determine the level of each competencies possessed by graduate Qs. Cognitive domain involves knowledge and the development of intellectual attitudes and skills.

4.4.1 Rationale of using Bloom's Taxonomy

Curriculum comprises of student learning outcomes which describes the knowledge, skills, and attitudes that students acquire through successful completion of a course. However, competency is an integration of knowledge, skills and attitudes. Thus, learning outcomes in the curriculum is a direct measure of competencies possessed by graduates. Further, as identified by Bloom (1956), cognitive domain of Bloom's Taxonomy involves knowledge and the development of intellectual attitudes and skills, thus competencies. As a result, it is crystal clear that Bloom's Taxonomy can be used to identify the level of competencies possessed by graduate Qs.

4.4.2 Analysis based on Bloom's Taxonomy

Bloom's original Taxonomy has six categories. Each category in it was given a score level depending on the chronological order of attainment. With that, knowledge, comprehension, application, analysis, synthesis and evaluation were given the scores of 1, 2, 3, 4, 5 and 6 respectively. And then, each learning outcome in the curriculum was given a level by referring to Bloom's Taxonomy. It was done by considering the verb in each learning outcome and assigning to it a level, based on the category of the verb. Following figure 4.4 summarises the verbs attributable to each level within the cognitive domain.

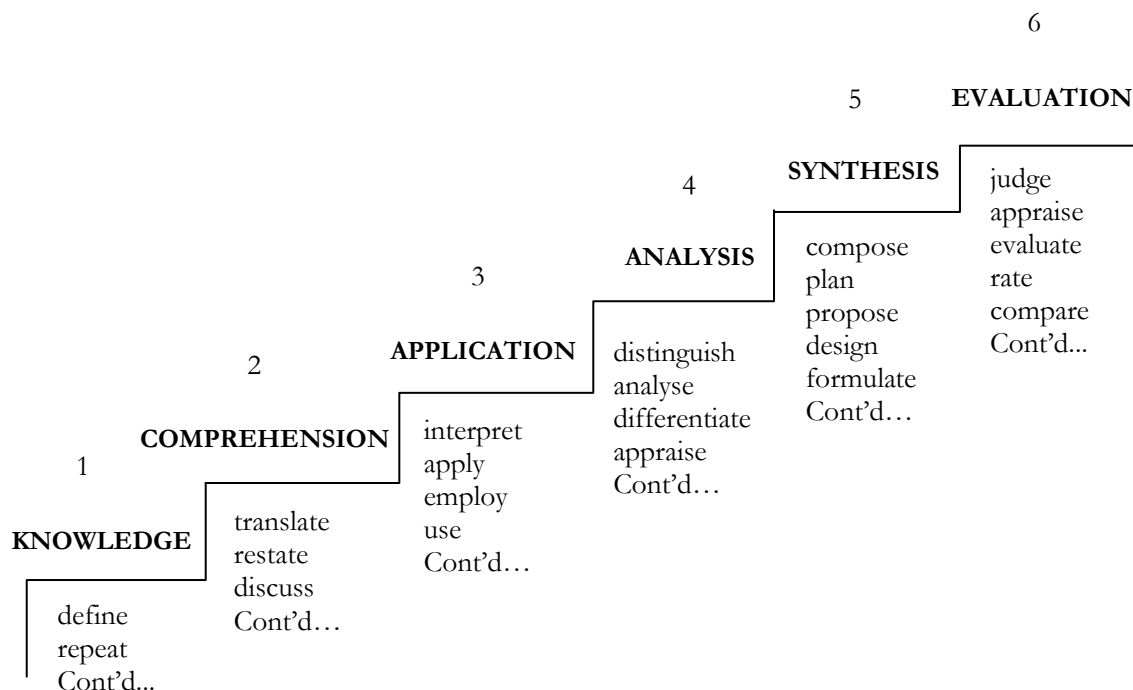


Figure 4.4: Verbs in each level of Cognitive domain

Source: Munzenmaier & Rubin, 2013

For example, if the learning outcome is ‘manage the post contract quantity surveying duties’, the level attributable to this learning outcome is 5, since the verb ‘manage’ is under Synthesis, which has been assigned a score of 5.

Subsequently, the individual learning outcomes were grouped under the list of competencies identified from the curriculum. For that, the following formula was used.

$$\text{Competency Level} = \frac{\sum (\text{Credit Value per Learning Outcome} * \text{Level})}{\sum \text{Credit Value per Learning Outcome}}$$

Employing the same method, level of each competency possessed by graduate Qs was calculated, as represented in Figure 4.5.

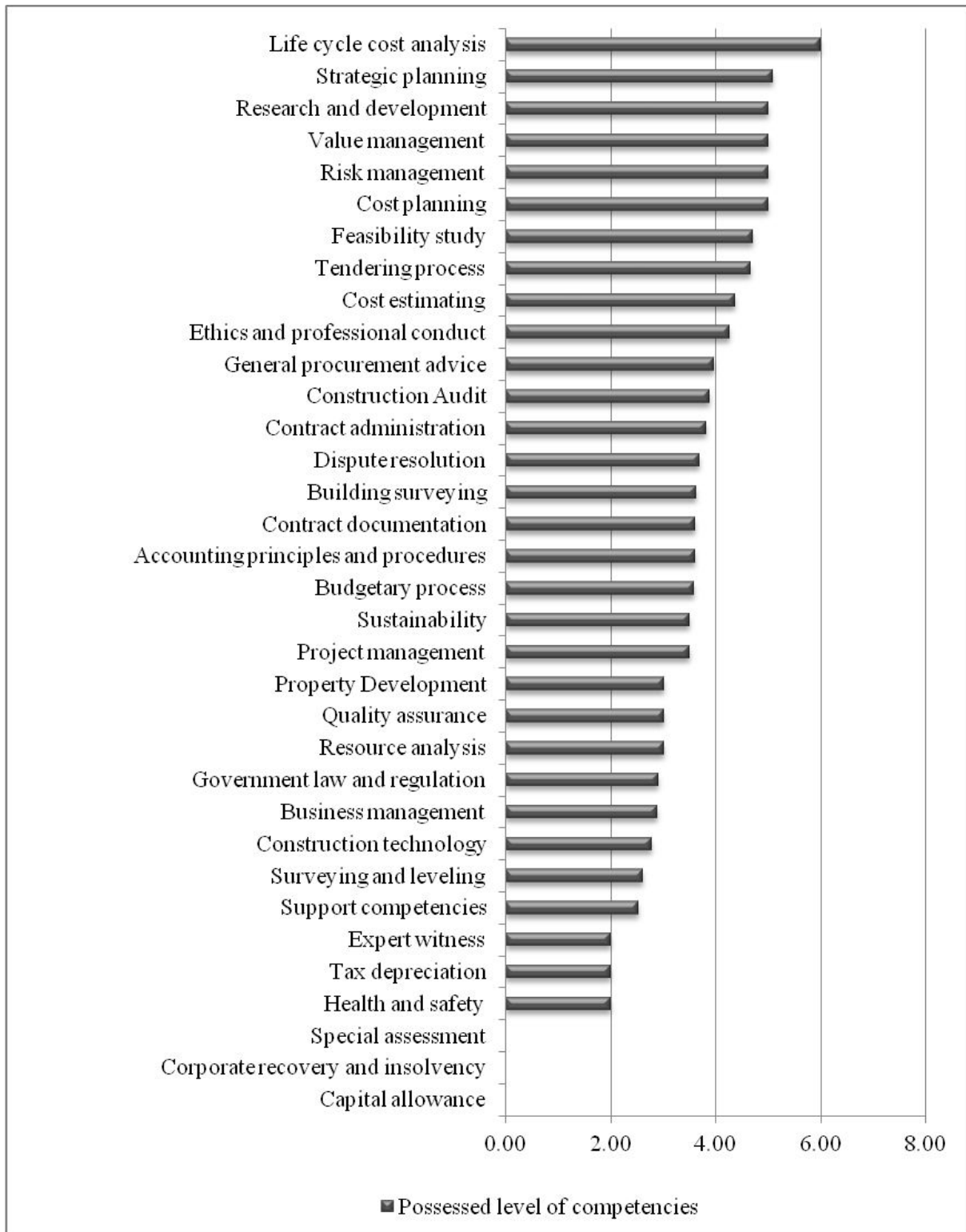


Figure 4.5: Level of competencies possessed by graduate quantity surveyors

From Figure 4.5, it is clear that Capital allowance, Corporate recovery and insolvency and Special assessment are not possessed by graduate QSs. Further, Cost planning, Risk management, Value management, Research and development, Strategic planning, Ethics and professional conduct and Life cycle cost analysis are possessed by them at a higher level. Hence, the third and fourth objectives of this study are accomplished.

4.4.3 Limitations of the study

The research has undergone with the following limitations.

- There is no weightage given in the curriculum, for the learning outcomes. Thus, learning outcomes within one module were considered to have equal credit values.
- When grouping the learning outcomes under the list of competencies, some learning outcomes were categorised under two or more competencies. For example, 'apply the capital budgeting techniques for financial decision making' was grouped under Strategic planning. However, it is an integral component of Feasibility studies too. Hence, the above learning outcome was categorised under both Strategic planning and Feasibility studies.

5.0 Conclusions and recommendations

As described at the outset, though the quantity surveying education system focuses on producing versatile graduates, the construction industry expects graduate QSs to diversify themselves that go beyond the original scope of the curriculum. Further, new opportunities and expectations of the industry reinforce the need to upgrade the competencies of graduate QSs so that they can withstand the threats and challenges that confront them. Hence, this study comparatively analysed the requirement and the possession of the competencies of graduates by the construction industry.

The external desk review conducted to ascertain the competency standards insinuated by IQSSL, RICS, AIQS and PAQS substantiated the competencies required from graduate quantity surveyors under 30 topics. These competencies were then grouped under the six themes, being 'Construction Economics', 'Construction Technology', 'Construction Management', 'Construction Law', 'Construction Information Technology' and 'Business Administration', to provide a broader perspective. Under the internal desk review, the analysis of the curriculum used by a QS Degree program accredited by the above local and international professional organisations revealed that all the required competencies, except Capital allowance, Corporate recovery and insolvency and Special assessment, were possessed by graduate quantity surveyors. In addition, Building surveying, Surveying and levelling and Property development were possessed by them, though not required by the professional organisations. The analysis of the curriculum referring to Bloom's taxonomy found that Cost planning, Risk management, Value management, Research and development, Strategic planning, Ethics and professional conduct and Life cycle cost analysis were possessed by the graduate QSs at higher levels. Further, Health and safety, Tax depreciation and Expert witness were possessed at lower levels. With that, the aim of this research was accomplished.

Finally, the study recommends certain developments for the local and international professional organisations as well as to quantity surveying education institutes. The development of a qualitative benchmarking system by professional bodies to indicate the level of competence required from graduate QSs. That could be used by the educational institutes to appraise the quality of their degree program. Next, the curriculum used by quantity surveying education institutes must be proactively audited to address all the competencies outlined by the relevant local and international professional associations addressing the aforementioned important subject areas. Further, it would be a great assistance to quantity surveying education institutes to upgrade their curriculum, if this research can be extended to identify the competencies expected from graduate QSs by the construction industry, and to map it with the competencies possessed by them. The outcome of this would be an important aid for the graduates to acquire competencies that are expected out of them by the industry.

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Influence of urban water bodies on microclimate and thermal comfort: Case study of Beira Lake, Colombo

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Abstract

This study explores the possibility of urban water body induced city cooling in the Sri Lankan context, with special reference to the Beira Lake, Colombo.

The research method utilises the computer simulation tool ENVI-met to explore

- *The effectiveness of an urban water body in influencing the microclimate.*
- *A water body in comparison to an urban green space of similar magnitude.*
- *Microclimatic and thermal comfort changes within selected sites of specific orientations, encompassing existing and simulated morphology.*
- *The effect of, and on the wind pattern around the lake in a holistic design scenario.*

The simulated results and analysis were limited to the peak time of the day of 14.00hrs of a single day in March.

Conclusions show that contrary to established thinking the Beira Lake has a negative effect on the thermal comfort, yet will facilitate better wind and evaporative cooling potential in the immediate surroundings.

Keywords: *Urban Water Bodies, Urban Heat Island, Outdoor Thermal Comfort, Warm Humid Tropics, ENVI-met, Sri Lanka*

Introduction

The urban heat island (UHI) effect develops when cities replace their natural land with impervious surfaces, buildings, and other infrastructure (Jauregui, 1997; Liu & Weng, 2008; McMichael, 2000). The UHI effect already produces elevated temperatures in city centres therefore urban design has a key role to play in reducing the UHI to create safe and pleasant places in which to live and work. Increased surface porosity and water bodies have a role to play in increasing potential cooling through evaporation. (Hathway & Sharples, 2012)

Water bodies form urban cooling islands (UCI) to mitigate the UHI effects. (Sun & Chen, 2012)

The aim of this study is to develop better understanding of the relationship between urban microclimate and water bodies in general and thermal comfort in particular.

The Beira Lake in Colombo, Sri Lanka is taken as the focus of the research, both for its prominent geographical position in the city and the rapid development happening around it.

The results of this study look to provide insight into climate-conscious urban design that incorporates large water bodies as tempering agents, to ameliorate the negative effects of local warming in a warm humid context.

Background

Starting from the early historic cities to the new urban cities, water has been used for architectural purposes. From the inception of our species, coping with the availability – or unavailability – of water resources has been an essential element of human beings' strategies for survival and well-being. Throughout history human ingenuity was manifested in the means by which water was procured, transported and allocated for various uses. The quality, distribution,

seasonality and amount of water have been key determinants of subsistence, health and settlement potentials. (Hassan, 2011)

The classical architectural language applied to the cities has included the waterfront and water crossing, serving to comprise the water element in a cohesive architectural language. The river settlements, which were to become great cities, had originated in harmony with the water edge. (Wylson, 2013)

Relationship of Urban Water Bodies, UHI and Outdoor Thermal Comfort

The urban microclimate is closely correlated with the types and patterns of landscape in the urban environment. One of the main reasons of UHI effect, are changes in the thermal properties of surface materials and lack of evapotranspiration through lack of vegetation and water bodies in urban areas. Water, is matter, which has a high heat bearing capacity and acts as medium of evaporative cooling in hot humid regions. Evaporative cooling is a physical phenomenon by means of which typically into surrounding air, cools an object or a liquid in contact with it. Latent heat, the amount of heat that is needed to dry up the liquid, is drawn from the air. (Szokolay, 2005)

The combination of the moisture content in the air provided by a water body and the blowing potential of the wind may strongly affect the microclimate conditions of an urban area, leading to a milder thermal environment. (Masiero & de Souza, 2013)

Fanger's thermal comfort equation shows that high humidities can be rewarded by the lower air and radiant temperatures. Although it is generally assumed that the primary cause of thermal discomfort is humidity in the tropics, studies have shown that at lower air temperatures of humidity effect on comfort is minimal. It reveals that carefully controlled humidity with shading can create thermal comfort. Thus, the potential of water in cooling is substantial even in the humid regions. However, care must be taken not overload the already heavy relative humidity of the tropics. (Emmanuel, 2005)

Water and Climate Sensitive Urban Design

Johansson et al, 2006, conducted a study in the coastal region of Colombo, Sri Lanka to find potential of sea breeze in cooling the urban outdoor areas, they found “In the weak wind regime of the tropics, another possibility is to induce wind flow by the thermal difference that arises at the edges of the water bodies. Differences in the thermal properties of land and water generate water/land breeze at day/night respectively. These wind-flow patterns could plan measures that promote deep wind penetration in to cities.” (Emmanuel & Johansson, 2006).

Emmanuel in 2005, suggests that, to get the maximum benefit from the water bodies

- Locate water bodies in every neighbourhood at the northern/southern corner of the city
- Connect major traffic roots water diagonally
- At larger scale, rearrange the street network to take advantage of the air movement
- Plant trees around water bodies to increase cooling potential of the air

Coutts et al, 2012 presents the concept of Water Sensitive Urban design (WSUD). WSUD provides a mechanism for retaining water in the urban landscape through storm water harvesting and reuse while also reducing urban temperatures through enhanced evapotranspiration and surface cooling. Research suggests that WSUD features are broadly capable of lowering temperatures and improving human thermal comfort, and when integrated with vegetation (especially trees) have potential to meet climate sensitive urban design objectives. However, the degree of benefit (the intensity of cooling and improvements to human thermal comfort) depends on a multitude of factors including local environmental conditions,

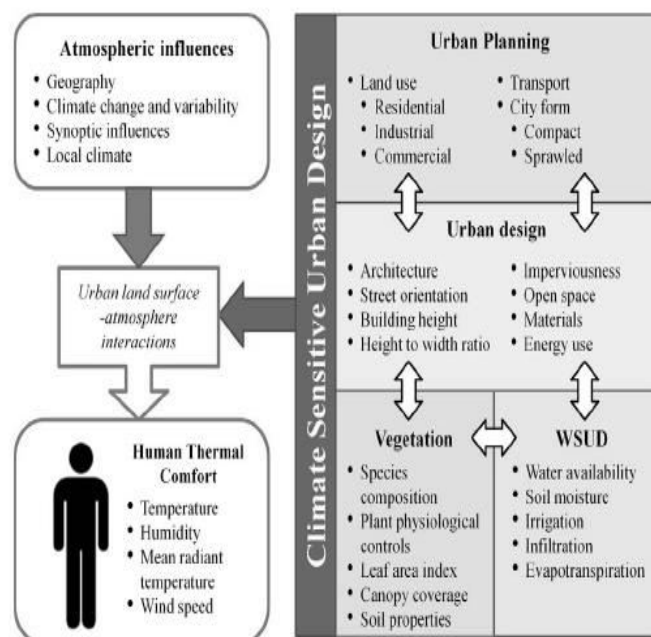


Fig 1- Conceptual diagram demonstrating the connection between Water Sensitive Urban Design and Climate Sensitive Urban Design.

Source - (Coutts et al., 2012)

the design and placement of the systems, and the nature of the surrounding urban landscape. (Coutts, Tapper, Beringer, Loughnan, & Demuzere, 2012)

Ishi et al. (1991), working on a 12.7 ha pond located in the central part of Fukuoka city, recorded a cooling effect of about 3°C up to several blocks downwind and especially during the afternoon hours. In some cities, the rivers crossing urban areas have been recorded as contributors to air purification (Fukuoka, 1997) and microclimate features (Murakawa, 1988; Katayama et al., 1991).

Sun et al., (2012) showed for Beijing, China; the relationship between wetland characteristics and Urban Cooling Island (UCI) intensity can provide useful action points for urban landscape design to mitigate the UHI effects.

- It is necessary to add water areas in big cities and keep them evenly distributed in dense, built-up areas, even though land use development pressures are also very high in those areas.
- The cooling effect of wetlands does not linearly correlate with wetland area. This indicates that the cooling effect has a threshold as the wetland area increases, and it is reasonable to benefit more stakeholders by substituting a large water body with several small water bodies of the same total area.
- The cooling effect of wetlands may be intensified by constructing them in a relatively regular shape because we do not have enough urban land to create wetlands.

(Sun, Chen, Chen, & Lü, 2012)

Evidence of the negative effects water bodies in urban areas was reported by Steeneveld et al., 2014 showed that; Based on weather observations by Dutch hobby meteorologists and a station network in Rotterdam (Netherlands), that water bodies increase rather than decrease the 95 percentile of the daily maximum UHI. The high heat capacity of water suppresses the diurnal and annual cycle over water, and water temperatures remain relatively high after evening and season transitions. This is reflected to the 2 m temperature above and in the surround of the water body, and in a relatively high UHI. (Steenefeld, Koopmans, Heusinkveld, & Theeuwes, 2014)

Similarly, (Perera, Emmanuel, & Mahanama, 2012) comparing the nocturnal cooling capacities (therefore UHI intensity in the urban canopy layer) of specific Local Climate Zones (LCZs) in Colombo, Sri Lanka, showed that the difference between 'LCZ-G-Water' to be warmer, than other LCZs in the land cover typologies. The study showed a 0.62°C UHI intensity. 'Local climate zones' (LCZs) comprises of a new and systematic classification of field sites for heat island studies. The classification divides urban and rural landscapes into 17 standard classes, each defined by structural and land cover properties that influence air temperature at screen height. (Stewart & Oke, 2012)

Method

The aim of the study was to explore the possibility of urban water body induced city cooling in the Sri Lankan context, with special reference to the Beira Lake, Colombo, Sri Lanka.

Within the primary objective the method is focussed on the following areas;

- The effectiveness of an urban water body in influencing the microclimate.
- A water body in comparison to an urban green space of similar magnitude.
- Microclimatic and thermal comfort changes within selected sites of specific orientations, encompassing existing and simulated morphology.
- The effect of, and on the wind pattern around the lake in a holistic design scenario.

The research method is based on the simulation and analysis of the existing and projected urban context. The steps of which are outlined below;

- Case study selection and site selection
- Simplify the existing built fabric as the existing (base case)
- Computer simulation of the existing selected areas and projected variations using ENVI-met. The projected variations are as follows;
 - Case study 01 - Change urban geometry according to LCZ simplification of urban context. (Existing Case)
 - Case study 02 - Replace the water body with a similar area of vegetation.(Green Case)
 - Case study 03 - Change urban geometry according to maximum UDA proposal development.(High density case)
- Data outputs of the computer simulations –Mean Radiant Temperature (MRT), Wind speed, Relative Humidity.

Site selection - Beira Lake, Colombo

The research focuses upon the Beira Lake and its environs; a distinctive landmark in the city of Colombo. It has reportedly been in existence for nearly five, centuries and once was a larger and deeper body of water, which had a strategic relevance to the ancient fort of Colombo. The lake has been gradually reduced to its present extent of about 65.4 ha from an estimated original extent of 162 Ha mainly due to reclamation carried out for construction of warehouses. It comprises four main basins the East Lake, the Galle Face Lake, the West Lake and the South West Lake. (Nahallage & Piyasiri, 1997)

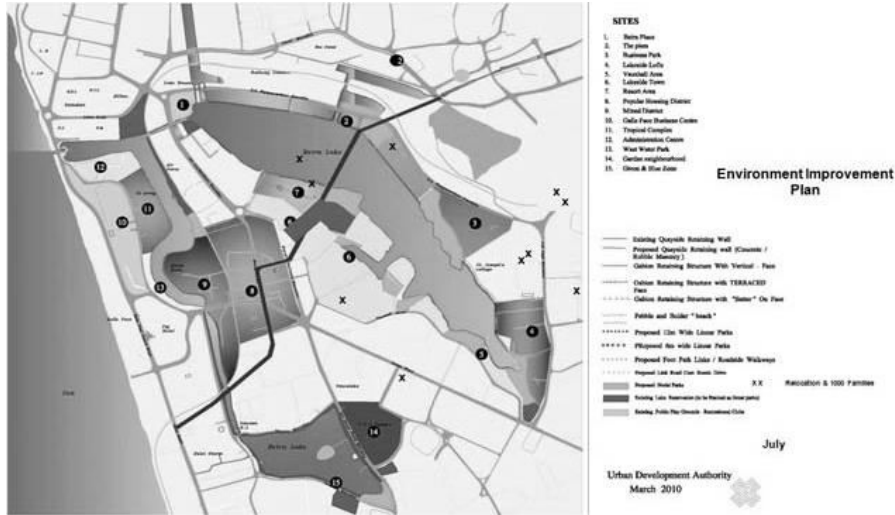


Fig 2- Beira Lake Master Plan - Source - (uda.lk)

The Defence and Urban Development Ministry has launched a massive project spanning over three years to renovate the Beira Lake to enhance the beauty of the city and to redevelop lands adjacent to the lake, for more productive uses. This project includes the construction of linear parks along the Beira Lake. All wastewater outlets including sewerage lines to the Lake are being disconnected. Families living in under developed settlements along the Beira Lake are to be provided housing units with more facilities in the condominium housing schemes under construction. Warehouses and garages by the side of Beira Lake will be relocated for more productive uses. (www.defence.lk last accessed 09.10.2014)

Simplify the existing built fabric and select representative sites

For greater applicability of the findings, a simplification of the urban fabric is adopted. This eliminates the changes due to the 'real world' heterogeneity seen in the urban fabric.

The simplification uses the Local Climate Zone (LCZ) system developed by Iain Stewart (Iain Douglas Stewart, 2011) and application of it for Colombo by (Perera et al., 2012) The LCZ system eliminates the ambiguity of the definition of what is 'urban' and what is 'rural', usually used in UHI reporting. Instead, the comparison is between classified classes. This leads to more efficient decision making for design and policy, where informed judgements can be made on the form of the urban fabric and therefore, its impact on factors like the local climate. Sites were selected around the water body depending on Local Climate Zone (LCZ) and Orientation (in relation to the lake)



Fig 3- Selected Sites

Simulation software - ENVI-met

Computer simulation tool ENVI-met is utilised to simulate the projected variations. ENVI-met is a 3-dimensional non-hydrostatic model for the simulation of surface-plant-air interactions, especially within the urban canopy layer. It is designed for micro scale with a typical horizontal resolution from 5 to 10 m and a typical time frame of 24 to 48 hours with a time step of 10 sec at maximum. The model has been extensively used in recent years in many urban areas, including in warm, humid regions and found to be an effective tool to estimate the local climate, air quality and thermal comfort effects due to urban growth (Bruse 2004).

The model does not express exact physical condition such as

contours and is built on a horizontal plane. A shortcoming of ENVI-met is that buildings, which are modelled as blocks, where width and length are multiples of grid cells, have no thermal mass and have constant indoor temperature. Moreover, albedo and thermal transmission (U-value) for walls and roofs are the same for all buildings. ENVI-met was validated for Colombo, Sri Lanka by Emmanuel, & Fernando, 2007.

The simulation scenarios are shown below;

Table 1 - Simulation Matrix

Scenarios	Urban Geometry	Green Cover
Base case (Existing)	to match existing geometry simplified as LCZs	None
Green case	same as base scenario	10 m (canopy) street trees at 20 m intervals (Stem height = 10m, without water body)
High density case	All buildings in the model area to be as tall as the urban development regulations will permit. (According to proposed zoning plan (2020) city of Colombo).	None

Analysis protocol

The data generated by ENVI-met is visualised using the ENVI-met add-on package LEONARDO 2014. The objective of the analysis is to ascertain the effect of the water body, therefore a system where the overall simulated is visualised becomes important. This is as opposed to point measurements, where other factors in the context, can affect the results. The analysis is limited to 14.00hrs on a particular day. The time is generally assumed to be the warmest time of the day. Iso-contour maps depicting MRT, RH and Wind speed are compared for the differently oriented sites for discussion on the impact of the Beira Lake on the context.

Results and Analysis

Site 'DR' (East) (Fig 4, 5, 6)

In the existing context, the MRT ranges from 27.7 to 65.95 °C. A replacement of the lake with that of a similar area covered with vegetation is seen push the MRT levels up, with a range 29.5 to 79.9 °C. Similarly, the high-density (HD) option too pushes the overall MRT range. (Fig 4)

At 14.00hrs, the lake surface is significantly warmer than the vegetated surface. Comparison of the 'existing' and 'green' case scenarios does not show significant variation in MRT values in the built areas around the lake. Although, in the HD case, the MRT change in the outdoors, especially adjacent to the buildings, show marked differences. The shade caused by the taller buildings decrease the MRT intensity. In areas where there are no buildings to shade the environs, the MRT values remain similar.

In terms of Relative Humidity (RH) the MRT differences between a vegetated area and the water body is very significant, with the vegetated area showing markedly lower values. As shown in Fig 5, the RH effects of the lake (existing case) penetrate deep into the urban fabric, resulting in comparatively higher values.

The HD case demonstrates that the taller building fabric blocks the RH flow, therefore beyond the initial buffer of buildings, the RH drops.

The wind shadow created by buildings, especially in the HD case, is clear. Reduction of the wind speed is evident in the green case, where it is understood that trees would hinder wind flow. This is seen on the lake edge, yet in the areas beyond the edge show similar characteristics.

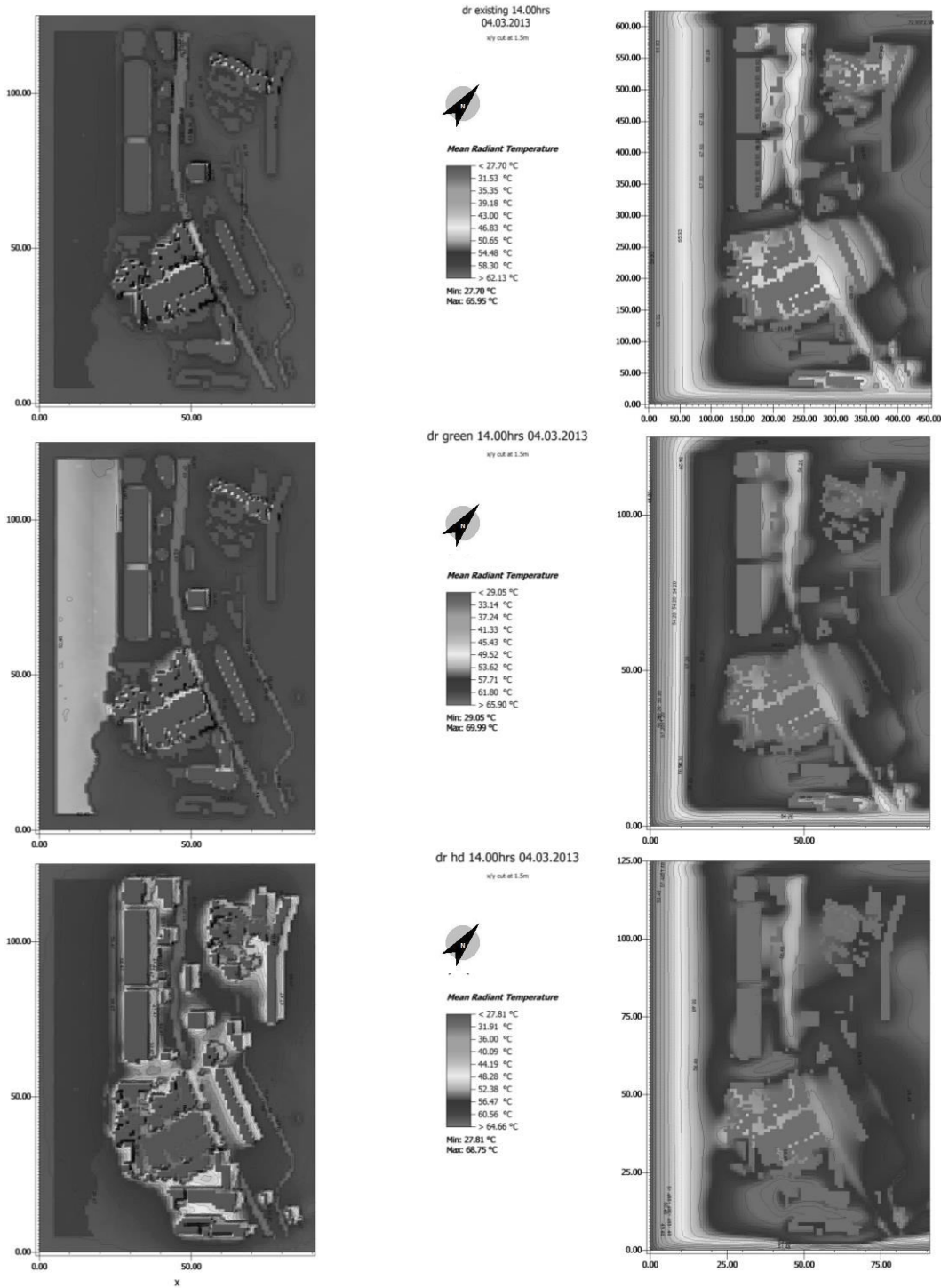


Fig 4 - DR MRT comparison

Fig 5 - DR RH comparison

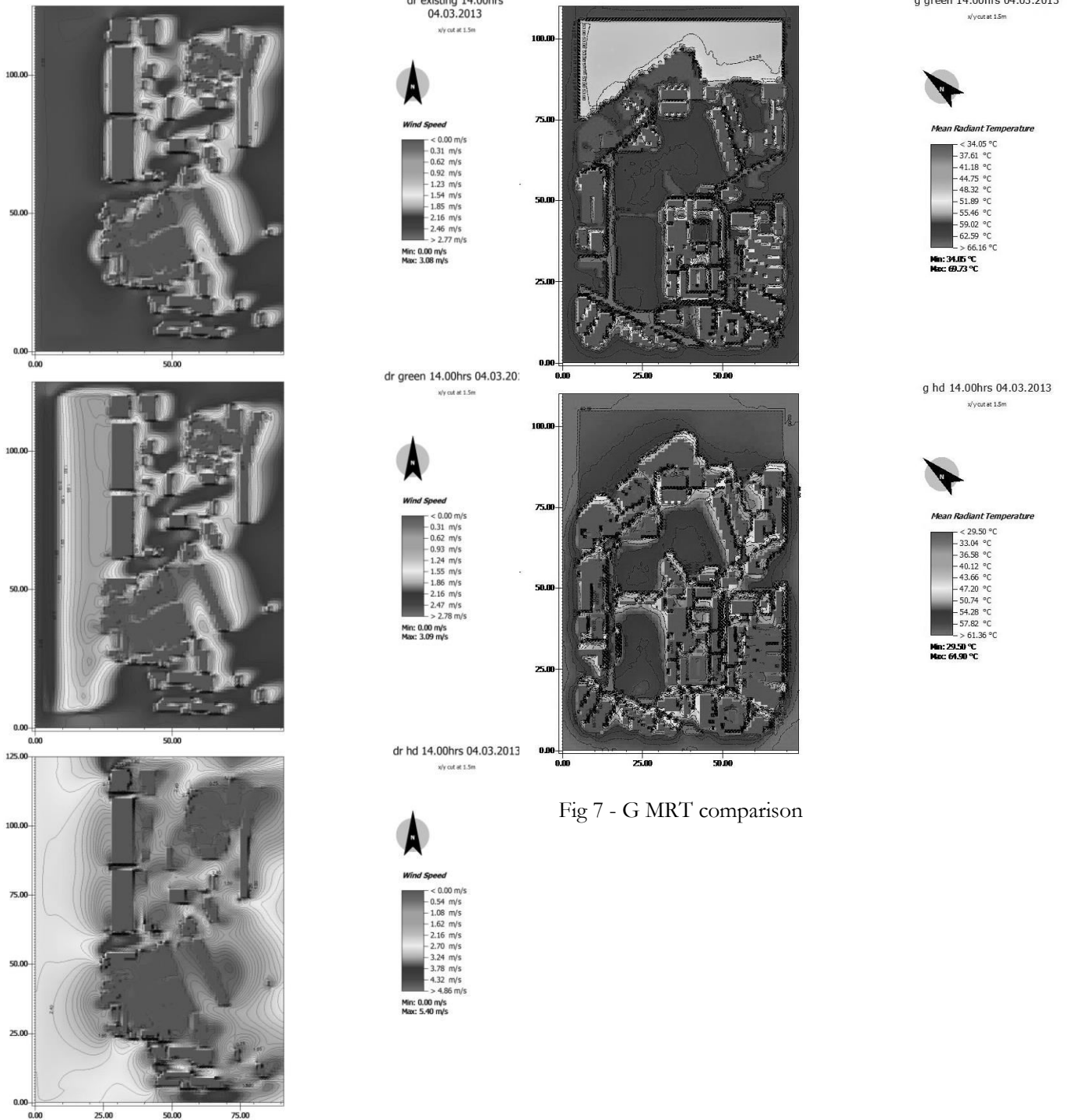


Fig 7 - G MRT comparison

Fig 6 - DR wind speed comparison

Site 'G' (West) (Fig 7, 8, 9)

The analysis compares the 'green' and the 'HD' cases only, caused by data errors for the existing case simulation.

Fig 7 portrays a similar MRT pattern to what is seen for site DR (East), where, the lake area is warmer than a similar green area, HD building fabric creates shadow and therefore cooler. The MRT intensity too, record similar values.

Unlike in the East bank (Site 'DR'), the RH differences seen in the green and HD cases where it showed similar, uniform penetration into the fabric. Here, the RH change for the green case is more rapid. (Fig 8)

The wind speed characteristics are as seen in the preceding site. Fig 9 shows higher values for wind speed at the edges

of the Iso-contour plot. This is due to the buffer zones used in the ENVI-met simulation, therefore deemed negligible.

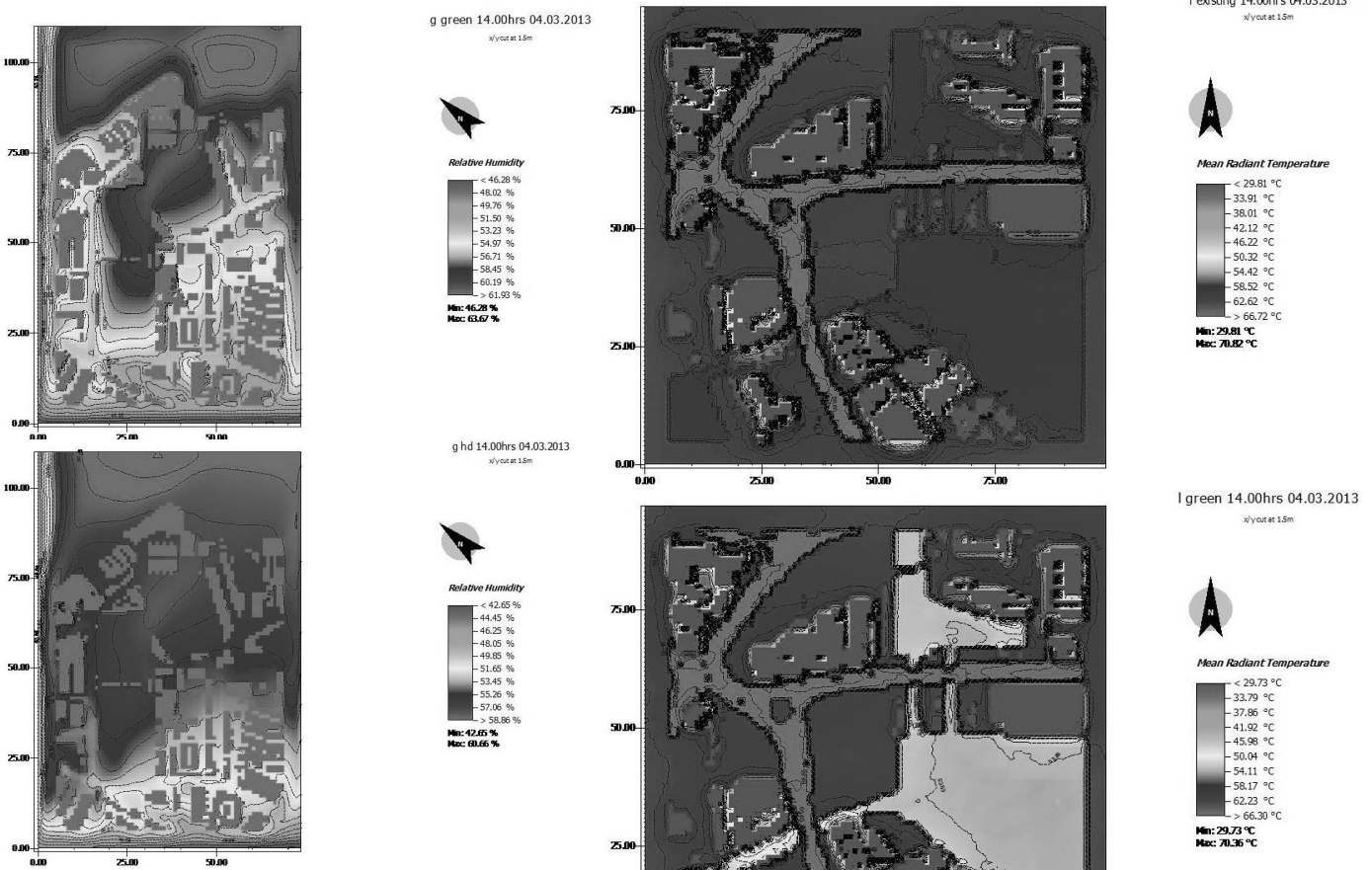


Fig 8 - G RH comparison

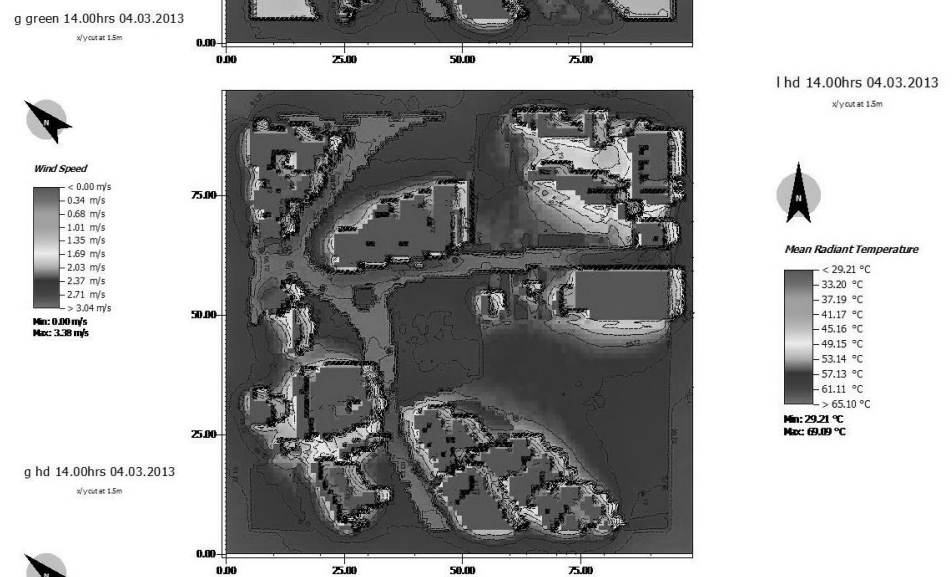


Fig 10 - L MRT comparison

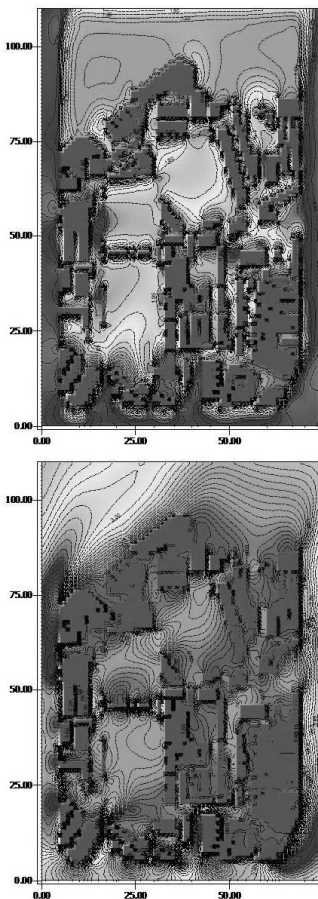


Fig 9 - G WS comparison

Site 'L' (North) (Fig 10, 11, 12) and Site 'P' (South) (Fig 13, 14, 15)

The sites show similar characteristics seen for the other sites. Thus, the change of geographic location and orientation in relation to the environs of the lake seems to have no effect. Yet, it must be noted that the simulation is limited to single day and time, therefore diurnal and seasonal effects of the sun path and wind are not taken into account.

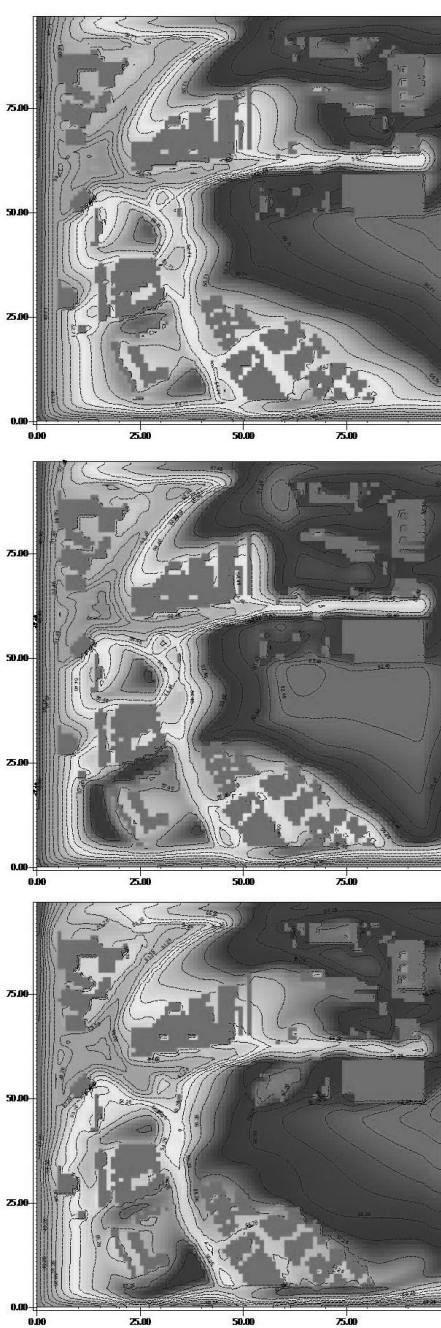


Fig 11 - L RH comparison

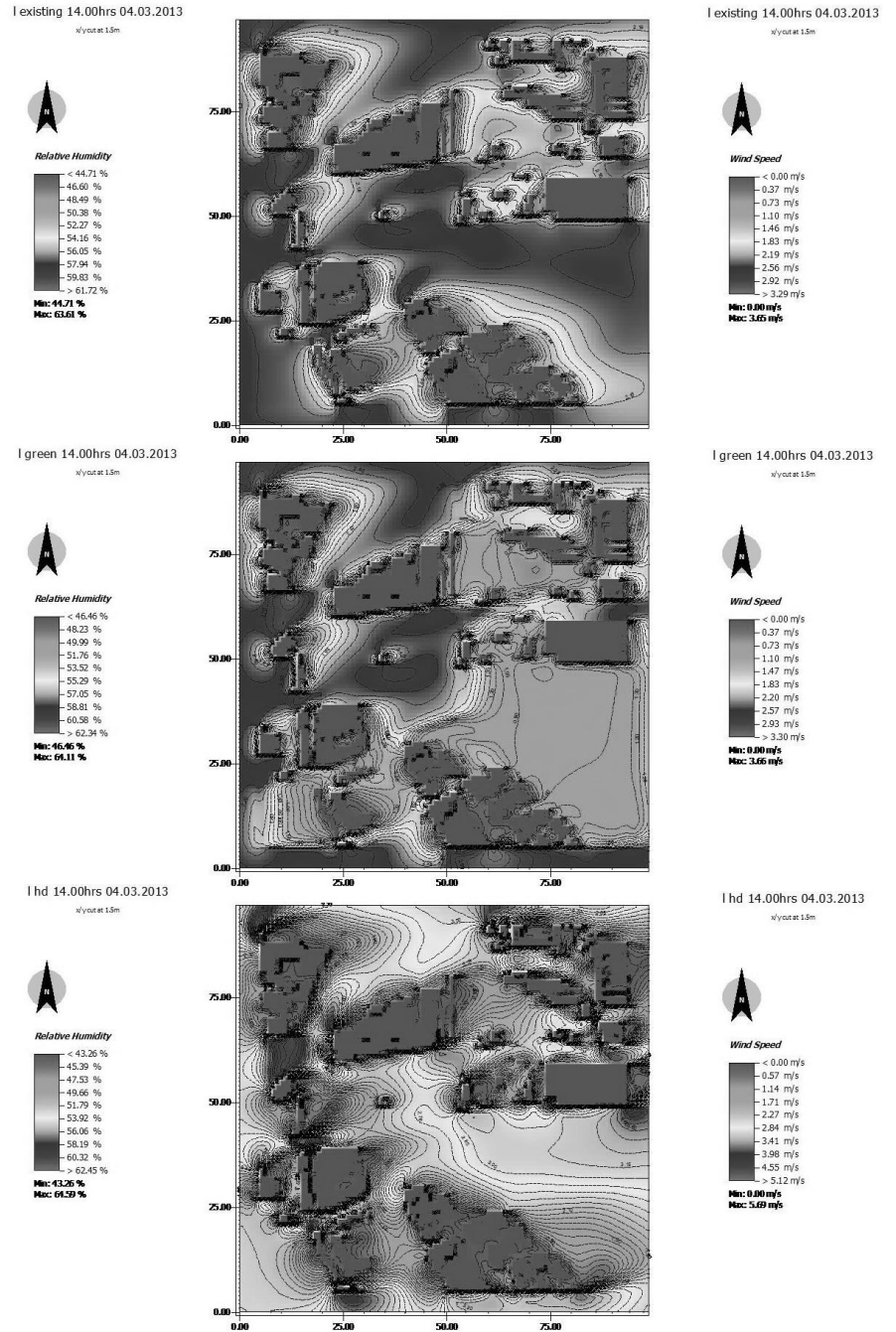
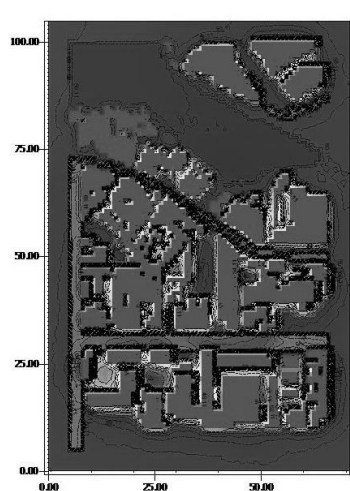


Fig 12 - L Wind Speed comparison

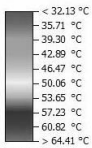


p existing 14.00hrs 04.03.2013

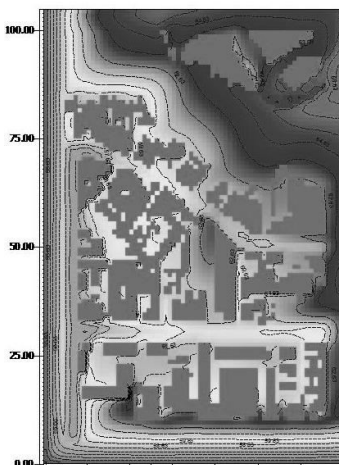
x/y cut at 1.5m



Mean Radiant Temperature



Min: 32.13 °C
Max: 67.99 °C

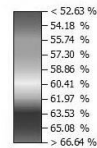


p existing 14.00hrs 04.03.2013

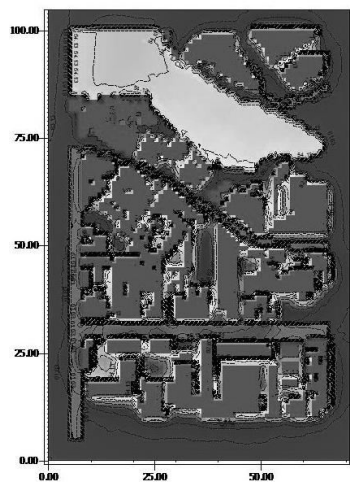
x/y cut at 1.5m



Relative Humidity



Min: 52.63 %
Max: 68.20 %

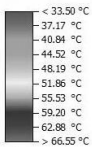


p green 14.00hrs 04.03.2013

x/y cut at 1.5m



Mean Radiant Temperature



Min: 33.50 °C
Max: 70.22 °C

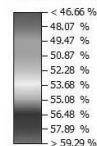


p green 14.00hrs 04.03.2013

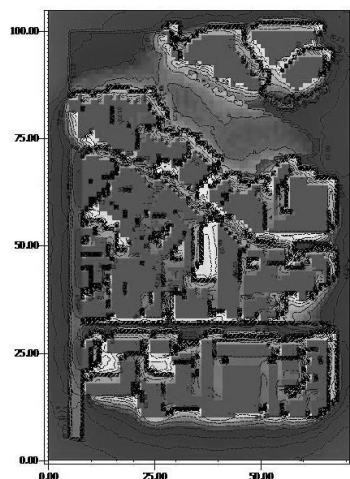
x/y cut at 1.5m



Relative Humidity



Min: 46.66 %
Max: 68.69 %

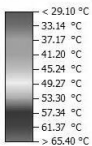


p hd 14.00hrs 04.03.2013

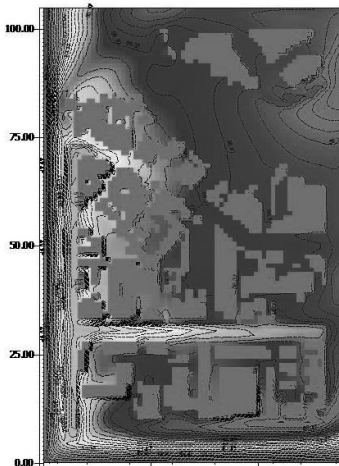
x/y cut at 1.5m



Mean Radiant Temperature



Min: 29.10 °C
Max: 69.43 °C

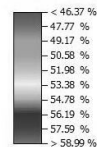


p hd 14.00hrs 04.03.2013

x/y cut at 1.5m



Relative Humidity



Min: 46.37 %
Max: 69.40 %

Fig 13 - P MRT comparison

Fig 14 - P RH comparison

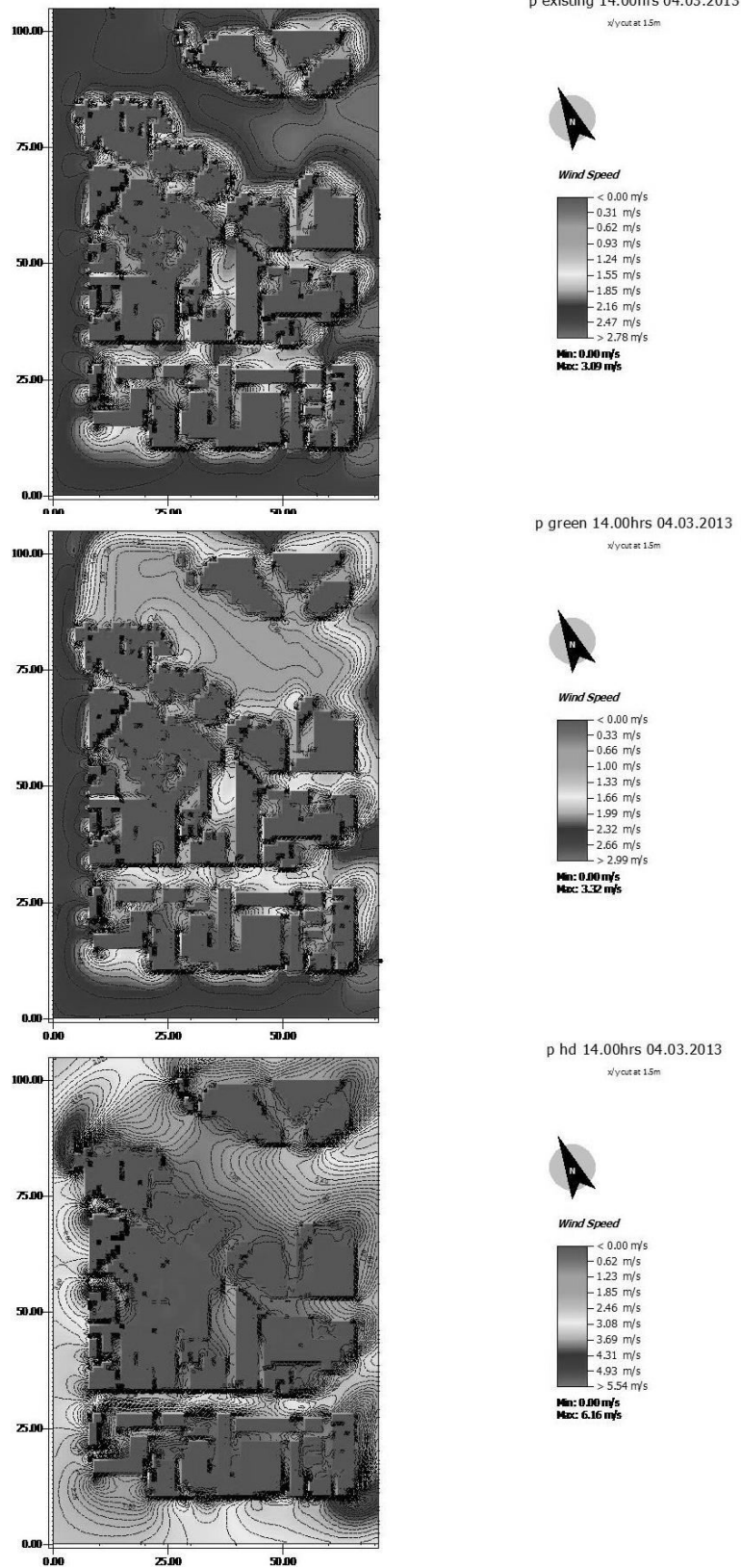


Fig 15 - P Wind Speed comparison

Summary of findings and Implications

The simulations of existing and projected cases show that;

- MRT intensity of the lake surface is warmer than that of the built fabric that surrounds the lake perimeter. Unlike established research discussed above, the Beira Lake in Colombo does not create a 'cool island' at the peak time of the day considered in the analysis. The difference in MRT in the built fabric is more building morphology (and therefore shade) induced rather than by the evaporative cooling potential of the lake. The implications of an urban

water body as a UHI mitigation strategy is not applicable for the peak time of day. Although, research shows that it can have a positive effect as an open area that can offer essential wind paths into otherwise heavily built up-areas in a city.

- A similar 'green' area that would hypothetically replace the lake is cooler in terms of MRT. There is minimal difference in MRT intensity between the two cases in relation to the areas between buildings, the impact of the green space is confined to the boundaries of such an intervention.
- A green option adversely affects the wind speed and RH at the edge of the lake. Yet, the simulations show similar values for the two variables, deeper into the built fabric. The effect of a green space is more local than that of a large water body. If the focus is on creating thermal comfort in specific areas, a green space is more advantageous, while the water body option has more far reaching advantages for areas of the fabric extending beyond its confines.
- The HD options create cooler areas in the immediate vicinity of the buildings. Yet, has a negative affect for both wind speed and RH flow. Thus, restricts the use of ventilation and evaporative cooling options to ameliorate the ill effects of local level warming. High-density development for shade creation must be developed in such a manner that it does not impede the positive effects of natural areas in the city. Air paths and breezeways need to be either maintained or introduced to create such possibilities.
- Characteristics of variables do not vary significantly in relation to the orientation of the sites on the banks of the lake.

Conclusion

The study is a reasearch initiative to ascertain the effects of a urbanwater body on the thermal comfort, relative humidity and the wind speed in the immediate environs of its siting. The 'Beira Lake' in warm humid Colombo was chosen as case study.

The simulated results and analysis were limited to the peak time of the day of 14.00hrs of a single day in March. Research concludes that for the peak time of the day;

- An urban water body has a negative effect on the immediate environs as opposed to a vegated area of similar magnitude.
- Positive aspects are seen in the wind speeds it maintains and/or induces.
- High Density bulding fabric has advantages only for the areas in close proximity of the buildings. They adversely effect the overall wind speed and evaporative cooling potential of natural areas in the city.

Future research needs to encompass the effects of such natural areas in the city such as the Beira Lake, for the complete hours of the day as well as distinct times in the year, thus, allow for a wider base of data and better analysis.

The challenge of future research and its application is to deepen the knowledge in relation to established urban interventions and strategies in general and urban water bodies in particular, yet draw upon the unique microclimatic context of Colombo, Sri Lanka.

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Sustainable Public Procurement Process in Construction Industry: Literature Review

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ABSTRACT

The procurement process in the field of construction plays a significant role in changing world in both public and private sector. The Public PP (Public Procurement Process) mainly focuses satisfaction of the stakeholders in line with the development objectives of the country. The importance of public expenditures within the world economy has stimulated and established interest in how public money is spent, with an emphasis on transparency and openness through the Public PP. Though a new concept to the developing countries, SPPP (Sustainable Public Procurement Process) is not another type of procurement; it rather seeks to address the environment, social and economic consequences of procurement actions from the initial stage through the design, implementation up to the end of defect liability period of the construction project. At present, the communities in Asian region are faced with worsening climatic conditions, poverty, deforestation and other environmental degradations. The developed countries have implemented the SPPP successfully as a solution to the challenges and gaps of existing procurement process.

Hence, the SPPP has identified as most accepted cost effective alternative method to address the challenges and gaps of the existing procurement process in construction industry.

Thus, this research paper mainly focused to identify the best practices of the SPPP to the construction industry of the developing countries through the secondary data with special emphasis to the Sri Lankan context due to the reason that economy of the country strive to transition to upper middle income country. Hence, relevant areas scrutinised through the critical literature review to explore the applicability of adopting SPPP to the construction industry in developing countries.

Keywords: *Public Procurement Process, Construction Industry, Sustainable Public Procurement Process*

01. Introduction

Procurement process is used by not only the government entities but also the private organisations to obtain goods, works, and services by most appropriate manner. Further, the World Bank (2010) described that public procurement is the process use by the government entities to buy the inputs for vital public sector investments. Those investments both in physical infrastructure and strengthen institutional and human capacities lay foundations for national development. Accordingly, public procurement mainly consider the stakeholder satisfaction in line with the desired objectives of the country, where, the primary objective of the procurement process in private sector is optimum benefit to the organisation together with least cost and accepted quality in line with the desired objectives of the organisation. Hence, enhancement and improvement of the activities of Public PP (Public Procurement Process) in construction industry directly benefitted to the nation in order to uplift the living standard of the community. Therefore, Public PP is explored as series of activities that significant to the sustainable development of the country. The activities of the procurement identified as continues processes from risk assessment, selection of source, evaluation of alternative solutions, contract award, payment, and management of a contract up to the end of defect liability period (Murray, 2009; Manu and Agyeman, 2005; National Procurement Agency, 2006; Erridge, 2007; Larson, 2009; World Bank, 2010). Further, the Public PP in construction sector was the main driver of economic growth in developing countries and it makes the most significant contribution, reflecting the massive public investment programmes and several private sector projects. Furthermore, revealed that interest of the stakeholders in construction industry has growth to moderate the existing process. Moreover, the procurement process in construction industry was identified as very sensitive to change in line with the requirement of external environment of economic, political, financial, legal and technological (Williams et al., 2007; World Bank, 2010).

Thus, the construction industries in the world are striving to tackle these changes through the new and innovative ways of construction, efficient resource utilization and better organization of the activities of the projects (Rameezdeen and

Silva, 2002). Accordingly contemporary version of the existing procurement process that link with requirement of external environment as per the global needs has identified as SPPP (Sustainable Public Procurement Process). Further, SPPP has concluded as integral part in order to achieve the present global needs and uplift the economy of the country and living standards of the stakeholders (Kim & Shunk, 2004; World Bank, 2010; Srivastava, 2007; Preuss, 2009; Walker & Brammer 2009; Nijaki & Worrel, 2012; Williams et al., 2007).

Hence, the aim of the paper is to identify the best practices of the SPPP to the construction industry in developing country. The scope of this paper limited to literature review on the SPPP in the field of construction. Accordingly focuses on the critical literature review to identify the best practices of SPPP as one of cost effective remedial measures to the challenges and gaps to the Public PP and bridge the gaps in construction industry of the developing countries to achieve broader sustainable development objectives with special emphasis to the Sri Lankan construction industry.

02. What is sustainable public procurement process (SPPP)

Sustainability means the capacity to maintain the entity, outcome, or process over the period of time (Solow, 1993). The concept of sustainability came to public attention after the 1972 based on the report of "Limits of Growth" that issued by the international think tank Club of Rome. In 1980 the world conservation strategy developed by the International Union for Conservation of Nature, in collaboration with UNEP (United Nations Environmental Programme) and World Wildlife Foundation, worked to make sustainability as a benchmark of international action. Accordingly, World Summit on Sustainable Development (2002) first time officially disclosed to the world the sustainable procurement as the process that promotes policies encouraging development and diffusion of environmentally sound goods and services. The World Commission on Environment and Development's report (1987) internationally recognised definition of sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The procurement actions in order to achieve desired outcome are same on the sustainable and existing procurement process (Interagency Procurement Working Group, 2006). Steurer et al. (2007) and McCrudden (2004) argued that existing procurement process has drawn special attention on the traditional elements of cost, quality and time than the contemporary elements of social, environment and economic in order to achieve the value for money.

Further, Walker and Brammer (2009) stated that the sustainable procurement process does not differ greatly from the existing procurement process. It incorporates an initial stage to determine the effect of the procurement action in terms of a desired outcome that is both elements of environmental and social as well as an additional stage at the end of the process to monitor and assess to achieve the net effect of the desired outcome.

As defined by Brammer, S., & Walker, H. in 2010 p. 453, sustainable procurement is a process *"whereby organizations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole life basis in terms of generating benefits not only to the organization, but also to society and the economy, whilst minimizing damage to the environment"*.

Hence, Sustainable procurement means taking sustainability considerations into account in the procurement actions. This means thinking carefully before buy, buying only what really need, purchasing products and services with high environmental performance and considering the social and economic impacts of a purchasing decision. Further the SPPP is the process that is consistent with the principles of sustainable development, such as ensuring a strong, healthy and just society, living within environmental limits, and promoting good governance. Furthermore as McCrudden (2004) noted, sustainable public procurement places government in two roles by "participating in the market as purchaser and at the same time regulating it through the use of its purchasing power to advance conceptions of social justice". Moreover the World Summit on Sustainable Development (WSSD) in 2002 called for governments to "promote public procurement policies that encourage development and diffusion of environmentally sound goods and services" (WSSD, 2002).

Besides the large market share, public procurement affects sustainability because it has a large direct impact on the environment and the society due to the large scale and the type of services it provides (Preuss, 2009). Through sustainable procurement a significant contribution can be made to reducing environmental and social damage, further, it facilitate to formulate more positively to the greener and more equitable society (Kjollerstrom, 2008).

The SPPP intergrade requirements, specifications and criteria that are compatible and in favour of the protection of the environment and social elements with support to the economic development of the country by seeking resource efficiency, improving the quality of products and services in line with ultimate optimizing cost (Walker and Brammer, 2009). Hence, the SPPP has given equal weightage not only to the traditional elements of time, cost and quality but also to the contemporary elements of social, environment and economical when acquisition of goods, works and services

with consideration of value for money. However the procurement process which not considers social and economic elements called as green procurement. Besides, SPPP attempts to use enhanced objectives when comparing with existing procurement process (Interagency Procurement Working Group, 2006; Steurer et al. 2007; McCrudden 2004; National Procurement Agency, Sri Lanka, 2006; Williams, 2007).

Wales (2014) revealed that public procurement account from 10% to 15% of GDP among developed countries and up to 15% to 25% of GDP in developing countries. The importance of public expenditures within the world economy has stimulated and established interest in how public money is spent, with an emphasis on transparency and openness within public expenditure processes (Heald, 2003; Midwinter and McGarvey, 2001).

Accordingly, the SPPP is about spending public funds on products, services, projects that foster sustainable development of the country. Currently, sustainability issues becoming vital in the developmental agenda of nations, hence, it is time to shift the focus on immediate economic advantages systems which will result in long term benefits not just to governments but to all their constituents. Though a new concept, SPPP is not another type of procurement; it rather seeks to address the environmental, social and economic consequences of procurement actions from design through manufacturing to use and final disposal at the end of defect liability period. SPPP is defined as a process whereby public institutions meet their needs for goods, services and works in a way that achieves value for money on a whole life basis in terms of generating benefits not only to the organization, but also to society and the economy, whilst minimising damage to the environment. Further, SPPP considers the environmental, social and economic consequences of: design; non-renewable material use; manufacture and production methods; logistics; service delivery; use; operation; maintenance; reuse; recycling options; disposal; and suppliers' capabilities to address these consequences. Finally the process upholds the principles of transparency, fairness (to both the supplier and society), long term economy, and accountability (Mueller 1997, Persson and Tabellini 2001, Shleifer and Vishny 1998, Strauch and Von Hagen 2000, Tanzi and Schuknecht, 2000).

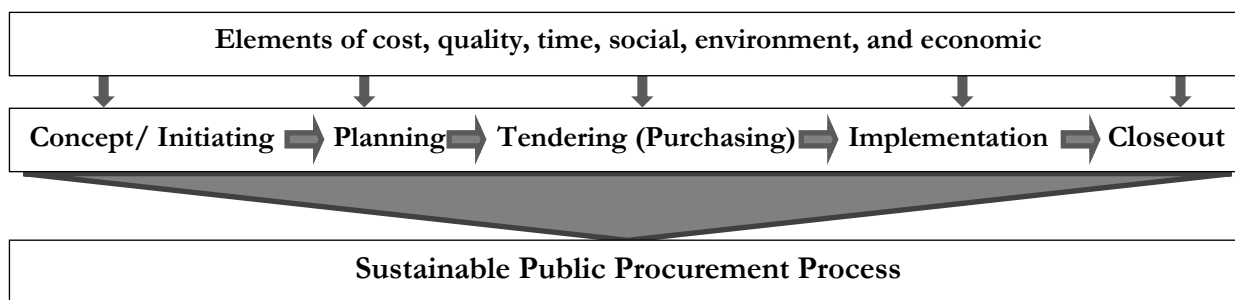


Figure 2.1: Sustainable public procurement process

03. Significant of “SPPP” in construction industry

The sustainable procurement is affected to potential saving of costs of the procured goods, works and services. Although it may lead to higher direct purchasing costs, though the overall lifetime cost of a sustainable product less than the cost of other cheapest options. Hence the sustainable option can result in lower operating costs, maintenance and disposal costs. Thus, despite the higher initial purchasing costs, sustainable options can offer an important return on investment through reduced life cycle cost of the construction industry. Further, it results in an average decrease of overall costs for public organizations of around 1% (Pricewaterhouse Coopers, 2009). This percentage is based on lifecycle cost estimation for seven European countries (United Kingdom, Sweden, Finland, Denmark, Germany, Austria and the Netherlands). A reduction of 1% is significant in absolute terms, given the large value of public procurement. The cost reduction could be larger for nations with a higher percentage of procurement of the GDP, such as developing countries (The World Bank, 2012).

Williams et al., (2007) highlighted that the new trends in SPPP and global need of upgrade the Public PP in construction industry as the global population is increasing and consumption rates per capita are growing. Hence, human consumption of resources significantly exceeds what the earth can provide. Further, essential services such as clean air and water, a stable climate and viable forests and fisheries are in long-term decline. The resources on which rely are being depleted at accelerating rates. Therefore, the authors stated that range of social, environmental and economic objectives can be delivered to the construction industry through the SPPP.

The SPPP is identified as most accepted method to address the issues and deficiencies in the existing Public PP (Interagency Procurement Working Group, 2006). The governments being the largest single buyers, it is evident that

governments buy and acquires in terms of goods, works and services with contributing significant ability to deliver sustainable development. Hence, the purchasing power of the government should rather be used to support contractors that produce sustainable products, e.g. recycled paper and hybrid products. Government procurement therefore needs to consider sustainability issues as it is the only way that it can be sure to offer real value for money over a longer term without compromising environmental and social responsibilities. This would ensure that development targets are achieved through the acquisition of goods, works and services to the construction industry without much damage to society and the environment.

With the considerations of UNEP (United Nations Environment Programme) (2011) found that the SPPP in construction industry seeks long term impact on economic, social and environmental issues, by helping to: achieve value for money, sustain economic development, improve ethical behaviour of suppliers / contractors especially, and the general public at large; reduce harmful emissions and waste generation; improved air and water quality; make local industries applying SPPP internationally competitive; increase the wealth and health of the society by improving living standards, improve working conditions and safety, labour standards; reduce labour agitation; improve condition of disadvantaged groups in the country; help accelerate the achievement of the Millennium Development Goals, and create a better society, among other things.

Accordingly, the main benefits from sustainable procurement can be summarized as: controlling costs by adopting a wider approach to whole life costs, achieving internal and external standards complying with environmental and social legislation, managing risk and reputation of the organization creating new, vibrant markets ensuring security of sustainable supply for the future ensuring maximum community and financial benefits (Interagency Procurement Working Group, 2006). Hence potential benefits of sustainable procurement in construction industry include: long-term efficiency savings more efficient and effective use of natural resources reducing the harmful impact of pollution and waste reducing the impact of hazardous substances on human health and the environment encouraging innovation providing strong signals to the sustainable products market practical expression of organizations' commitment to sustainable development.

Since, the public procurement contribution to the budget of developing nations is often large (about 15% to 25% of the GDP) a well regulated SPPP has direct impact to expedite the sustainable development of the country (The World Bank, 2012). This will be visible in terms of efficient resource management including mainly in natural resources, social services delivery, increased projects delivery (e.g. schools, hospitals, and highways), accountability, transparency, competitiveness, fairness, promotion of growth of local industry. Further Public procurement influenced by social justice of consumer protection, societies, media, environmentalists, social activists, and other groupings.

04. Main principles and approach to the “SPPP”

The SPPP is a methodology with goal to encourage the public authorities to move towards more sustainable patterns in the public procurement that will be guided by following main principles (United Nations Environment Programme, 2010; Roos, 2012).

1. **Good procurement is sustainable procurement:** This is the basic principle, which underlies all the other principles and contains the core message that good procurement must take in consideration the three pillars of sustainable development which are the social, the environmental and the economic pillars.
2. **Leadership:** Champions, such as organizations and senior management, can demonstrate leadership by sharing best practices and encouraging others.
3. **Policy through procurement:** the SPPP can contribute to the delivery of a wide range of public and private organizational objectives.
4. **Enabling delivery:** the SPPP requires the communication of a consistent message designed for the needs of various internal and external audiences. The SPPP should be supported by clear lines of responsibility, with incentives and penalties for delivery.
5. **Implementing:** Implementation should be based on life cycle approach and on continuous improvement. Implementation should be supported by the principles of procurement and it should use a risk-based approach, demonstrate immediate success through quick-wins and ideally the SPPP should be integrated into organizational or environmental management systems.
6. **Monitoring results and outcomes:** Measuring improved environmental, economic and social performance.

Further, Walker and Brammer (2009) and Roos (2012) pointed out five key steps as approach to the SPPP as follows;

1. **Status Assessment:** The status assessment is a fast-track assessment based on an online questionnaire covering the three pillars of the SPPP to determine areas of success and areas where further work is needed. It can be used to check progress at a later stage.
2. **Legal Review & Market Readiness Analysis:** The legal review analysis assesses the national legal, regulatory, and institutional framework for public procurement and the legal possibilities to integrate the SPPP principles. The market readiness analysis assesses the availability of sustainable products and services, the responsiveness of the market, the national business sector response to potential SPPP and the capacity to meet current and future public procurement requirements for sustainable products and services.
3. **The SPPP Policy and Action Plan:** The national sustainable policy plan is expected to establish a clear direction and a mandate for implementing the SPPP. Elements should include objectives, priorities, products to concentrate on a commitment to communicate the policy to the relevant stakeholders and to monitor key objectives and outcomes.
4. **Training:** A training and guidance has been developed to raise awareness of the SPPP, provide the capacity to deliver training, and train staff from procurement, finance, legal, persons responsible for procurement and suppliers.
5. **Implementation:** Implementation of the SPPP takes into account sustainability aspects within the procurement process including whole life costing. It results in changes in products and services purchased as well as changes in behaviour of those involved in procurement. It leads to better products and services, which have less negative impact on the environment, help to save costs in the long term and contribute to social justice.
- 6.

Accordingly it was identified that six main principles and five key steps to approach the SPPP through the literature.

05. Challenges for the “SPPP”

Through the literature several potential challenges and barriers identified that limit the implementation and upgrade of sustainable public procurement practices. Accordingly, the following significant challenges have been analysed in significant areas through the numbers of studies on developing countries (Walker & Brammer 2009; Interagency Procurement Working Group, 2006; United Nations Environment Programme, 2010; Roos, 2012; McCrudden 2004; Mosters 2010; Barth et al. 2005)

Economic

The SPPP is often perceived as more costly which leads to pressure to buy the cheapest goods and services. Higher initial investments for sustainable products, tight budgets, and inflexible budget systems and accounting practices often pose an additional financial burden. There is also insufficient information on whole life cost of products and the relative cost of environmental friendly products and services.

Political

There is often a low awareness of the benefits of sustainable products and services which causes a lack of political commitment. Conflicting priorities can result in a lack of alignment of sustainable policies with national development objectives and organizational goals.

Legal framework

Interpretation of public procurement legislation is not always straightforward and procurement officials do not necessarily infer that the most economically advantageous tender should be the one with the lowest whole life cost. Hence, developing countries may need to modify their legislation to be able to incorporate sustainability criteria. Also, the legality of national legal provisions on SPPP may be challenged under international, regional or bilateral trade agreements if considered discriminatory.

Cognitive

In general, there is a lack of competence in sustainability matters and in establishing sustainability criteria. There is a further lack of practical tools and information, and training. The environmental and social issues are new issues for the officers in the field of traditional procurement in their purchasing decisions. Many public procurement professionals are unfamiliar with sustainable development principles such as whole life costing and calculating externalities (cost caused to the society) and they lack the legal knowledge on how to incorporate social and environmental criteria into tender specifications. Furthermore devolved or decentralized purchasing structure makes it even more difficult to manage SPPP across the board in all product areas.

Regulatory policies

There is discussion whether Public PP, or SPPP, is a cost efficient policy tool and whether it affects competition. This is compared to the use of economic policy tools that permanently change framework conditions such as taxes, subsidies, fees or emission permits. The literature argues that the consideration of environmental and social criteria is incompatible with the general principle of using only award criteria that are relevant to the procurement decision. These concerns include that SPPP would reduce competition, result in higher public expenditure, could be subject to misuse and increased corruption, and it could increase the administrative burden in particular for small and medium enterprises.

Accordingly the list of potential challenges and barriers was compiled by using the general barriers identified above. Hence through the literature incorporate some issues considered to play a role in developing countries such as high initial cost, lack of capacity, market readiness, and the negative impact on small and medium sized local companies to allow for individual inputs.

06. Remedies for the challenges of the “SPPP”

The implementation of SPPP will certainly not be without challenges there will be hurdles to be surmounted. However, the remedies outlined in this section address the implementation challenges. The challenges arise from the areas of Economic, Political, Legal framework, Cognitive, and Regulatory policies as discussed in previous chapter. Accordingly through the literature the challenges were summarised as getting a reasonable budget for the SPPP; availability of SPPP compliance officers; legal framework; budget holders; suppliers and contractors; entities; politicians. Considerable amount of funds need to implement the SPPP agenda. These can be sourced from government’s own funds or from the funding agencies. Further found that due to the benefits expected to accrue to the world at large funding agencies willing to support SPPP projects. For SPPP to work effectively there should be a class of officers to monitor and carry out audits to ensure compliance. This is a challenging task. Experts will have to be hired to train the officers. Country procurement laws need to be amended to introduce sustainability issues. Closely linked is the ability to integrate the SPPP issues into the Procurement Process itself. Experts can be outsourced to undertake this task (Walker and Brammer, 2010; Steurer et al. 2007; McCrudden 2004; Williams, 2007).

Further, it is pivotal to understand and remove challenges and barriers to have a successful transition process. The challenges to implementation of the SPPP can be removed through use of emerging Good Practices and implementation experiences from both industrialized developed and developing countries. The following elements of the capacity development framework are used by the developed countries and United Nations Development Programme (UNDP) to structure the remedial for challenges (United Nations Development Programme, 2010).

1. Possible root causes for challenges should be identified to determine possible actions.
2. The core issues of institutional arrangements, leadership, knowledge, and accountability, identified by developed countries and UNDP should be used to categorize ways to overcome challenges.
3. The situations where specific functional and technical capacities are central to remove challenges are indicated. These include capacities to engage stakeholders, assess a situation and define a vision and mandate, formulate policies and strategies, budget, manage and implement, and evaluate.
4. Management approaches that support the SPPP such as systems, concepts and tools are identified to complete the analysis.
- 5.

The literature found that in order to overcome challenges and barriers should be addressed to their root causes. Accordingly the following core issues need to be addressed: institutional arrangements, leadership, knowledge, and accountability (McCrudden 2004; Interagency Procurement Working Group, 2006; Steurer et al. 2007; United Nations Development Programme, 2010).

Institutional arrangements

Institutional arrangements have to be in place to perform the SPPP related tasks. Tasks include the find out required financial facilities and management of the SPPP mainstreaming process with dialogue of stakeholders. At the national level it may require legal and regulatory reform, the adaptation of existing tools and guidance material to the country situation, and support to public entities and suppliers in implementing the SPPP practices. Support arrangements may include the SPPP helpdesk, streamlined certification procedures, the financial facilitation of crossagency and donor funding agencies. Furthermore development of the SPPP training modules in cooperation with training institutions and similar management arrangements shall be placed at the procuring entity level.

Leadership

There needs to be strong leadership to understand and promote the concept of the SPPP. Leadership should establish the SPPP targets and manage results, provide resources and infrastructure, provide incentives, support overcoming bottlenecks, initiate innovation such as e-procurement, lead the dialogue with donor funding agencies and development partners, facilitate multi-agency cooperation, create conditions for new ways of doing things, and encourage behaviour changes and continuous learning.

Knowledge

The knowledge management is important to raise awareness on sustainable development and the SPPP to the general public. Knowledge management may include dissemination of information on the SPPP policy and action plans, and the provision of training for procurement practitioners, finance officers and the private sector. Knowledge management may also include access to external resources such as consultants and technical experts, the establishment of a credible training framework, and development of guidance material for practical use such as defining what inputs are needed to calculate whole life cost. The facilitation of other knowledge tools such as networking, best practice sharing, and websites is also important.

Accountability

The accountability ensures clear mandates and processes as remedy for identified challenges. Further the accountability ensures verification of sustainability requirements, value for money procurement, ethical rules to fight corruption, a system of rewards and sanctions, results measurement, reporting and rule enforcement.

Hence, the actions to remove or reduce challenges may need to address several issues depending on the actual situation and the root causes identified. Therefore the step by step should be followed in order to introduce and implement the SPPP by addressing challenges and barriers.

07. Status of “SPPP” in construction industry in developing countries

The current global procurement system in construction industry is aim to promote the standards of living and economy by providing output as desired by the stakeholders with the special attention on the requirement of end users. Hence, activities of the Public PP in developing countries are identified as key features of sustainable economic development in line with the current developing features of environment sustainability, social inclusion, regional competitiveness other than the traditional considered features of time, cost and quality achievement.

The construction industry is identified as an open system, hence, which is very sensitive to change with the needs and requirements of the stakeholders; further, its characterization throughout the world is determined by the operating external environment, which consists of subsystems such as economic, political, financial, legal and technological. This has led the industry to be in a challenging state in addressing the changes forced by the subsystems in an efficient and effective manner. Thus, the construction industry in developing countries is striving to tackle these changes through the new and innovative ways of construction, efficient resource utilization and better organisation of projects. Consequently, the Public PP practiced in the construction industry has also been subjected to changes resulting in many newly innovated procurement systems that could be used to meet contemporary requirements (Turin, 1973; Hillebrandt, 1984; Ofori, 1990; Rameezdeen, 2002; Walker and Brammer, 2010).

Therefore, the Public PP in construction industry in developing countries should give equal weightage not only to the traditional elements of time, cost and quality but also to the contemporary elements of social, environment and economical when acquisition of goods, works and services with consideration of value for money in line with the requirements of the stakeholders and the global needs (Interagency Procurement Working Group, 2006; Steurer et al. 2007; McCrudden 2004; Williams, 2007). Further it was identified that the Public PP in construction industry has committed itself to sustainable development practices of the country and funding agencies have generated procurement policies and practices which encourage the sustainable development and dissemination of environmentally sound goods and services. Although procurement policies exist in developing countries, very little is known about the extent to which sustainable procurement policies and practices are embedded within the practice of officers in both public and private sectors.

Findings suggested that there are several practical implications for the government policy makers in developing countries to successful implementation of SPPP. At the initial stage, the policy makers should focus more on “buy from small and local suppliers” as well as retain an environmental focus and address future policy iterations. Further the government also carried out investigation and feasibility studies to provide sufficient financial support, introduce

sustainable procurement guidelines, and implement the awareness raising programs about sustainable procurement opportunities. Finally, the assistant should be obtained from the funding agencies and developed countries in continuing to develop and refine policy responses to the sustainable procurement challenges ahead (Walker and Brammer, 2010).

The literature found that some of the government organizations in developing countries adopted few elements of sustainable procurement e.g. ensuring the safe incoming movement of product to an organization's facilities, purchasing from local suppliers, ensuring suppliers' location are operated in a safe manner, purchasing from small local suppliers and ensures that suppliers comply with child labour laws (Interagency Procurement Working Group, 2006; Walker and Brammer, 2010).

08. Conclusion and way forward

The aim of this paper was to identify the best practices of the SPPP to the construction industry with special emphasis to the developing countries in order to bridge the challenges and gaps of the existing Public PP in line with requirement of the stakeholders and the global needs.

As mentioned previously findings revealed that the SPPP has number of challenges and gaps to adapt to the developing countries. Further through the literature it was identified that numbers of practicable remedial measure to address the challenges and gaps of the SPPP as per the previous experience of developed countries in line with the requirement of the stakeholders and the present global needs (The Commonwealth Procurement Guidelines, 2005; Raymond, 2008; Walker and Brammer, 2009). Hence through the literature identified the feasibility of adopting the SPPP to the construction industry of developing countries with consideration of the aspects of social, environment, and economical while carrying out the public procurement activities as a best practice in order to promote the standard of living and economy. Further sustainable actions expedite the achievement of short terms target in order to facilitate to achieve the sustainable development of the country in line with the global requirements (World Bank, 2010; Murray, 2009; Larson, 2009).

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Traditional small retail shops vs. emerging supermarkets and shopping malls in a Sri Lankan city

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Abstract

Street retail shops are an emblematic image of the Sri Lankan urban landscape. Retail shops vary in size, sell a diversity of household, mechanical and convenience items and appear as an integral part of urban form. While retail shops provide essential services to a variety of consumers generate employment and make urban streets vibrant, there have been few investigations into the nature of retail form in Sri Lanka. It appears that the global spread of supermarkets and shopping malls are transforming the retail space in Sri Lankan cities. Utilising field observation data, this study investigates the extent to which traditional retail outlets dominate the retail form in the urban landscape, creates employment, and attracts customers. This study also examines to what extent city retail outlets are retained as shop houses. Results show that while Sri Lankan traditional small retail shops form a greater number of retail shops and continue to be an emblem of the urban landscape, the development of a few new shopping malls and supermarkets have impacted the daily shopping behaviour of people and are slowly transforming the retail form as well as urban landscape.

Keywords: malls, supermarkets, traditional retail shops, urban areas

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Introduction

Retailing forms an important aspect of Sri Lanka's urban function and landscape. Retail shops are pervasive throughout urban areas, with higher concentrations in town and city centres and within linear developments along the major roads and neighbourhoods in Sri Lanka. Retail outlets are scattered everywhere because unlike North America cities, Sri Lankan urban and rural spaces are characterised by mixed uses. Similar to retail shops in Asia and elsewhere in the world, Sri Lankan retail stores sell a variety of items for different socio-economic groups. They sell vegetables, fruits, electrical goods, pharmaceutical and other essential items. In terms of economic vitality, retail shops provide employment for people, particularly poor people, and improve the tax revenue of local authorities. Similar to other developing countries, Sri Lankan small traditional retail shops cater to middle and lower income groups, while supermarkets and modern shopping malls serve higher socio-economic status groups (Bromley, 1998). Sri Lankan retail outlets also provide economic and community vitality (Duany, Plater-Zyberk, & Speck, 2000; Jacobs, 1961). At the local level, retail shops, particularly in small traditional retail areas, make urban spaces vibrant. They provide spaces for people to interact, and thereby facilitate building and maintaining authentic communities (Gehl, 2010). Such small retail dominant areas not only make urban spaces live but also improve the perceived safety of pedestrians as retailing increases pedestrian movements in streets (Jacobs, 1961). Nevertheless, there are some planning implications associated with retail shops in most urban areas in Sri Lanka. For example, retailers tend to invade pavements/ footpaths though construction of illegal structures, ambulant traders often block pedestrian movements in street and footpaths and some markets are poorly integrated with other urban land uses.

Building on earlier work by Bromley (1998), this paper investigates the form of retailing in a Sri Lankan urban area and the extent to which traditional retail shops dominant the retail form in urban landscape. It also focuses the functioning of retailing in terms of employment generation, customer attraction, and to what extent city retail shops are retained as shop houses. The findings reveal that small retail shops form a greater number of retail outlets and therefore they contribute to a larger part of urban development. The results also show changing aspects of retail form and the transformation of urban form in the case study area: Katubedda in the Moratuwa Municipal Council area in Sri Lanka. Since the research focuses on retail form in Sri Lankan urban areas, the nature of this study is exploratory rather than definitive. The study findings primarily interpret the form of retail shops and transformation of urban spaces due to retail stores in the study area as far as possible with the available data sources. This study is a part of a larger research project related to the form and the transformation of retailing in an urban area. Therefore, it needs to be noted that this paper does not examine more on how the retail sector affect planning practices in Sri Lanka.

Retail development and physical planning in the case study area

This study was undertaken in Katubedda ward area in the Moratuwa Municipal Council area. In the case study area it seems that physical planning process in relation to retail development is reactive rather than proactive. Like many other urban areas in Sri Lanka, it appears that Moratuwa City Council promotes linear development along main roads without a proper zoning plan, planning guidelines and enforcement of zoning regulations (United Nations Centre for Human Settlements, 2002). It seems that planners may unintentionally contribute to the oversupply of small retail outlets particularly in existing residential areas. This undermines the residential character that is conducive to residential living leading to amenity impacts from proliferation of retail shops in urban areas. Planners and planning authorities sometimes fail to enforce laws to unauthorised retail establishments, unauthorised conversion of residential buildings for commercial activities and unauthorised filling of wetlands for such trading activities (Ratnayake & Butt, 2012). Similar to many other urban areas in Sri Lanka, retail activities have also affected mobility. Retail shops are located along the busy main roads that run through the town. In the case study area, these types of linear development activities are located along Galle Road as well as Campus Road (see Figure 1 and 2). Since many of these trading activities have direct access from the main road, it has naturally contributed to traffic congestion as well as a continuous inconvenience to the pedestrians (United Nations Centre for Human Settlements, 2002). The informal sector traders also fuel the situation by blocking the pavements or footpaths. The lack of parking facilities in retail areas also contributes to traffic congestion, as customers tend to park their vehicles on the roads.

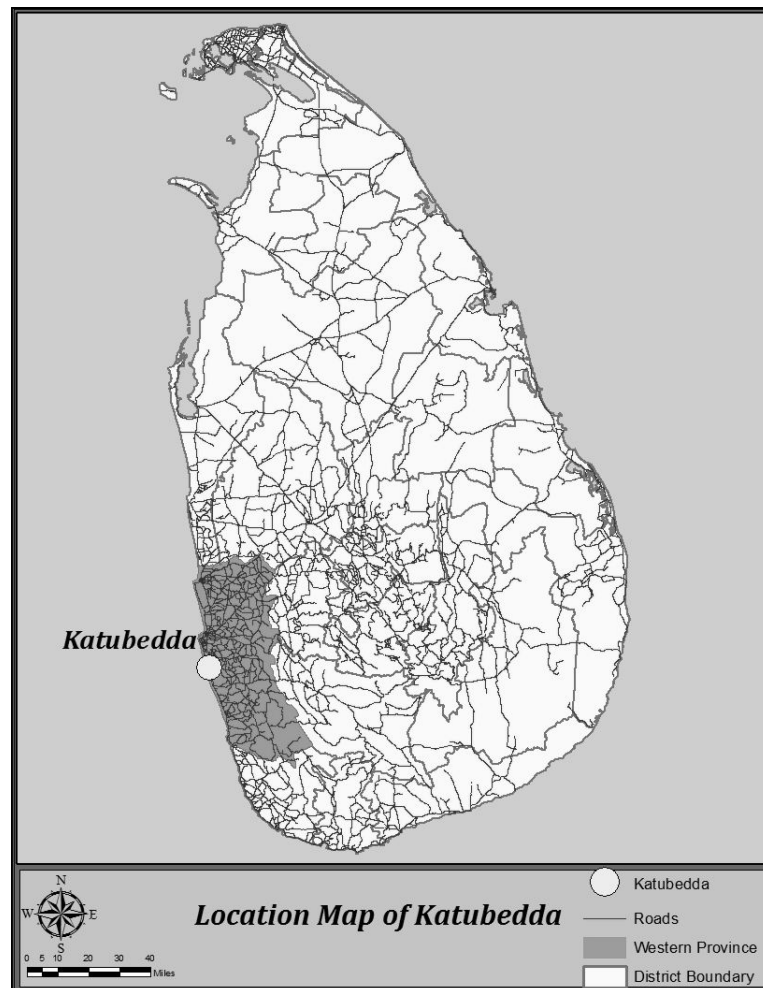


Figure 1: Location of case study area in Sri Lanka

Transforming of retail form and urban growth in Sri Lanka

Previous research has shown that the form of retailing for developed and less developed countries remain mostly different; however, there is growing evidence of global convergence. In cities of more developed countries, particularly cities in North American and Europe, the ubiquitous car-based shopping mall has become the standardised form of new retail development since the 1950s (Goodman & Coiacetto, 2012). The recent retail literature in Australian cities indicates that the global enclosed type shopping malls have been embraced to various degrees in different cities, and cities have proportionately a much smaller amount of traditional street-based independent retailing (Goodman &

Coiacetto, 2012). The retail literature for the less developed countries highlights that market-place trade and street-based independent shops continue to thrive within expanding cities and in linear developments along the major roads (Bromley, 1998; Skinner, 1985). In less developed countries, studies have identified many retail forms: traditional street-based independent shops, market-place trade, supermarkets, ambulant or informal retail outlets and less common, shopping malls (Bromley, 1998; Romo & Reardon, 2009). Similar to other developing countries, retailing also comes in many forms in the cities of Sri Lanka. For example, *pola* (farmer's markets), street-shops, informal/ambulant traders, supermarkets, traditional market centres and post-modern enclosed type shopping malls.

In Sri Lanka, it is not easy to define retail forms as boundaries between various forms are often blurred. However, they can be classified according to location, size, and type of goods on sale. *Pola* are usually open-air markets on a concrete platform or on streets. They often operate in fixed sites in towns or villages on periodic days. Street-based retail shops usually operate in fixed sites and comprise permanent building structures. These shops are found on most of the main roads and street corners in cities and are also scattered in random fashion throughout neighbourhoods. Street-based shops are generally small in size and operate throughout the week. Traditional market centres comprise many fixed shops that are occupied by traders operating on a daily basis or on market days. They are mostly located in the historic centre of the town or city and tend to be contained within one-story buildings. Supermarkets, usually two-storey or three-storey buildings comprising a variety of shops and operate on market days. They are also mostly located in town centres. Supermarkets in Sri Lanka are therefore having some similarities with traditional markets. The shopping malls tend to be the largest markets, and they are found mostly in cities in Sri Lanka. Most of the modern supermarkets and shopping malls provide plenty of parking facilities. The informal or ambulant traders, often on streets or pavements, tend to be mobile and they may not have permanent structures. The ambulant traders remain stationary for long hours throughout the week. Similar to *pola* and fixed retail shops, they sell foodstuff, household items and a variety of manufactured items. Therefore, as indicated in past research, the boundaries between the forms of *pola*, street-based retail shops, ambulant trading and supermarkets in terms of goods on sale are ambiguous (Bromley, 1998).

The form and location of retail shops have been affected by the introduction of open economic policies in Sri Lanka since the early 1980s and the impact of these policies seem to support trade as the retail sector has continued to flourish in the last two decades. Since the 1980s, a variety of state-owned supermarkets such as Sathosa supermarket and LakSathosa chain of supermarkets have been established in most of the urban areas. The state also encouraged private sector investors to establish modern supermarkets such as Cargill's, Laughs and Keels supermarkets, particularly during the last two decades. These supermarkets have been located in main urban centres and they attract mainly upper class and middle income customers. There has also been a growth of planned shopping malls in inner city areas during the last three decades (Liberty Plaza, Magestic city and K-Zone). Nevertheless, the growth of closed type shopping malls has been relatively slow compared with modern supermarkets and street-based traditional retailers. These shopping malls mostly attract high status customers.

Apart from the previous retail types, new special economic trade centres have been established under the Sri Lankan Ministry of Trade and Commerce. These centres are located in high-density urban areas of Dabulla, Ratmalana, Norochchola, Talawa, Narahenpita, Anuradhapura and Meegoda (Wedaarachchi, 2009). Similar to the Victoria Market in Melbourne (Goodman & Coote, 2007), these trade centres are large in size compared to traditional open air or semi-open air '*pola*' (farmers' market). They comprise a variety of retail outlets such as fish, vegetables, eateries, household items and other essentials. It appears that the new special trading centres attract particularly middle and low-income customers as these traders sell their items at wholesale prices.

In developing countries, the changes to the retail form and proliferation of traditional street-based retail shops have been related to urban growth, increasing household participation in marketing process and increasing efficiency of transport (Skinner, 1985). It was observed that during the last three decades, the population densities in major cities in Sri Lanka were increasing at an average rate of four percent per annum (Department of Census and Statistics Sri Lanka, 2010). The commuter population has also increased in major cities due to increasing activities in urban areas such as service sector and industrial sector employment (Urban Development Authority, 1999). In recent years, it has also been observed that the frequency of public and private transport facilities, particularly public buses, have increased in urban areas along with the urban growth in Sri Lanka. Therefore, in Sri Lanka, similar to many other developing countries, the growth of population densities, the frequency of public and private transport facilities and household participation in market process tended to increase demand density and foster emergent alternative global retail forms such as supermarkets, hyper or modern supermarkets and shopping malls (Skinner, 1985; Bromley, 1999). The demand density continues to support street-based independent retail shops, traditional market centres and ambulant traders or pavement hawkers.

In developing countries, the growth of street-based retail outlets and pavement hawkers or 'informal sector' is associated with not only demand density but also poverty in these countries. In less developed countries, due to poor economic conditions of the state, the poor do not receive sufficient welfare payments and in some instances, there are no safety nets for youth. However, the cost of living is increasing on a daily basis (Dholakia, Dholakia, & Chattopadhyay, 2012; Lawson, 1995). This situation has tended to result in increasing numbers of people engaging in petty retail shops such as street-based small shops and ambulant trades or pavement hawkers (United Nations Centre for Human Settlements, 1996). Although many studies explored the evolution and the transformation of retail trade in developed and less developed countries, the focus of the form of retail trade, its transformation and operation in urban areas in Sri Lanka has been neglected. Therefore, this study attempts to shed light on the form, changing aspects of retailing and transformation of urban form due to unplanned retail expansion in a Sri Lankan city area.

Case study area

The research project was carried out in the Katubedda area. The Katubedda is located within the Colombo District in the Western Province of Sri Lanka. Katubedda area is a suburb of Moratuwa city in Sri Lanka. The Moratuwa city area population was about 185,000 people while the Katubedda area population was about 27,000 in 2010 (Department of Census and Statistics Sri Lanka, 2010). Katubedda ward has the largest population as well as has a fairly high density of population, about 100 people per/ ha in 2010 compared to the average density of population in the city (78 people per/ ha)(Department of Census and Statistics Sri Lanka, 2010). Katubedda and the Moratuwa city area population has grown at very high rates during the last six decades. The Moratuwa city area population was only 50,698 in 1946, and it had increased by over 350% by 2001. According to the City Profile of Moratuwa(Department of Census and Statistics Sri Lanka, 2010; Moratuwa Municipal Council, 2002), the city reached its peak population growth rate of 4% in 1981 and it is about 2.5% per annum at present. This high rate of growth is mainly due to attraction of migrant workforce by its service sector activities, industries and urban sprawl from Colombo and Dehiwala-Mt.Lavinia Municipal Council areas. Even though it has not been properly estimated, Katubedda area attracts a significant number of commuters to the area on any working day during the daytime. People commute to the area for employment, engagement in commercial activities, and or to attend educational institutions.

The case study area is known for its skilled traditional carpentry works and furniture industry (Moratuwa Municipal Council, 2002). Kadubedda and its nearby areas also have rubber product, transformers, and batter industries. Katubedda is also home to Moratuwa University, the most well-known technological University in Sri Lanka. This suburb includes the famous Arthur C Clark centre and popular high schools such as Prince of Wales and St. Sebastian's College. Katubedda area also comprises many banks and financial institutions such as the Bank of Ceylon, People's Bank, Seylan Bank, Commercial Bank and Seylinco Insurance companies. Furthermore, an international cricket stadium, Tyronne Fernando Stadium, is situated in Katubedda. In recent years, it has been observed that the population growth and the above-mentioned urban activities have created a demand density that helps the retail sector to flourish in the case study area(Urban Development Authority of Sri Lanka, 2005).

Method of study

This study is focussed on field observations and interviews undertaken during 2012 along the major roads with linear retail development in Katubeddacampus area in Moratuwa Municipal Council Area. The research investigated the form of retail provision along the streets and the transformation of retailing in Katubedda area. The field observations were done in three site areas in Katubedda campus area: street retail outlets located along all roads within 100m of the University of Moratuwa, the road from University of Moratuwa to Katubedda junction which comprises about 750m strip, and 500m either side of the Katubedda junction along the Galle Road. The site areas are shown in the figure 2.

Three stages were involved in the research. The first stage comprised field observations that were utilised to identify and map retail shop locations, measure the size, form of retailing (mall, street-based retail shop, ambulant retail outlet or a shop house,) and type of activity (type of goods on sale). In Sri Lanka, it is common for municipal councils to monitor and maintain a registry of fixed retail outlets in their council areas. However, local authorities often do not have reliable data sources in terms of ambulant traders, type of activity, classification or spatial maps of retail outlets.

The Second stage involved the classification of retail shops and form of retail shops in the project area. Since the local authority or any other local administration agencies do not have a formal retail classification system in Sri Lanka, the authors classified retail shops according to the type of consumer goods on sale. In the retail literature, retail classification has been conducted in a similar way; therefore the retail activity groups classified in this study are consistent with past studies (Ghani, 2005; Juhasz, Seres, & Stauder, 2005).

When it comes to retail form, it is not easy to distinguish one form from the other because retail forms or types are blurred. However, in the retail literature (Romo & Reardson, 2009), there have been attempts to define retail forms in

many ways e.g.: size, ownership, scale of operation and environment. Using the retail literature as a guide this study identified and classified four forms of retails in the case study area. The retail forms were classified based on the following characteristics:

1. Traditional street-based fixed retail shops: typically small/ medium scale, single-owner, often run by a husband and wife or 'mom and pop' or a family member or employee, not self-service, and typically carry dry goods/foods, packaged foods, and non-food such as detergents, or wet goods (produce, poultry, or meat).
2. Modern supermarkets: relatively large compared to street based stores, independent or chain of stores, self-service, often have air conditioning carry dry food, packed food, non-food (fast moving consumer goods such as detergents), wet food, fruits, vegetables, electronics and most of household items.
3. Shopping complexes or shopping malls: often large in size, found many stalls under one roof, self-service, in chains, and owned by corporate entities or independent single owner, often enclosed, air conditioned environment, electronic check-out counters, credit card systems, similar to modern supermarkets, often sell household dry goods, packed foods, wet goods, non-foods, electrical items and most of household items.
4. Informal retail outlets or ambulant traders: usually illegal occupants on the streets or open areas operate in non-fixed locations, often prices are not fixed or not shown, bargaining is accepted, not self-service, and they may operate daily at non-fixed hours. They have a variety of items: household goods, dry food, non-foods, wet goods such as meat or fish, fruits and vegetables.

The classification of retail shops and forms of retail outlets in the study area are shown in Figure 2 and Tables 1 and 2 below.

The third staged involved the observation of customers' behaviour in each fixed retail shops. At this stage, the number of customers that visited each fixed-retail shop in the study area were observed. Interviews were held with shop owners to collect information regarding the number of employees and age of the retail shops. The findings of all three stages were then analysed to identify the dominant form of retails, growth of mall type retail outlets, and transformation of urban landscape due to retail shops.

Study Findings

Results from the field observations and interviews about retail locations, retail forms, and the transformation of urban landscape due to retail shops are discussed in this section. The study area reflects the vibrant character of the retail sector and a variety of retail options in typical urban areas in Sri Lanka. The findings indicate that a large number of retail shops tend to be the small street based retail shops and their growth has been surprising during the last decade. The study area consists a considerable number of shop houses. As the data reveal, although there has been a slow growth of modern supermarkets and shopping centres in the study area, these retail stores proportionately attract a large number of customers. The findings also indicate that retail shops, particularly street-based small shops have contributed to convert residential lands uses into commercial land users.

Retail Forms in the study area

The field observation data identified three forms of retail provision in the study area: traditional street-based retails; informal sector traders; and shopping malls. The findings reveal that the majority of the retails (87%) were traditional street based retails. The study area also comprised 11% (n = 23) ambulant traders, a modern supermarket and a shopping mall. The study did not find traditional markets and Pola (farmers' market) in the study area although these retail forms exist in most of the urban areas in Sri Lanka. This is may be due to the small scale of the case study area and this area had not been a traditional urban centre. As previously discussed, traditional market centres and weekly Pola are mostly found in traditional city centres or towns in Sri Lanka. The retails forms in the study area are shown below.

Table 1: Retail forms

Retail Form	Frequency	%
Traditional street-based retail shops	176	87.6
Ambulant traders/informal sector	23	11.4
Shopping mall	1	0.5
Modern Super market	1	0.5
Total	201	100.0

As shown in the table above, the study identified a total of 201 retail outlets in the project area. Of 201 retail shops, 178 (87%) retail shops were identified as fixed retail shops. The remaining 23 (%) shops were informal traders who did not occupy fixed places to sell their goods (See Figure 2). They usually occupied footpaths or pavements to sell their items. Although informal trading has been a pronounced feature and it offers a wide variety of cheap food and manufactured items for all socio-economic groups in the study area and more general in all urban areas in Sri Lanka, this study biased towards the identification of nature, form and changing aspects of fixed retails. Therefore, this study did not take into account informal sector traders when analysing retail groups or categories, number of customers visited for retail shops and age of the retail stores.

Retail categories

All fixed retail shops were classified into 12 retail categories based on the types of goods for sale. The findings show that the area has diverse and relatively well-balanced retail sector. It appears that the prominent retail shops in the study area tended to be food and beverages (19%), stationeries and communication (14%), groceries (13%), health and personal care stores (pharmacies and herbal products) (11%), home furnishing and appliance (9%), spare parts shops (10%), and to a lesser extent, hardware, clothing, perishables, timber, aluminium, gift andbric-a-bracs shops. Retail categories are shown in Figure 2 and Table 2.

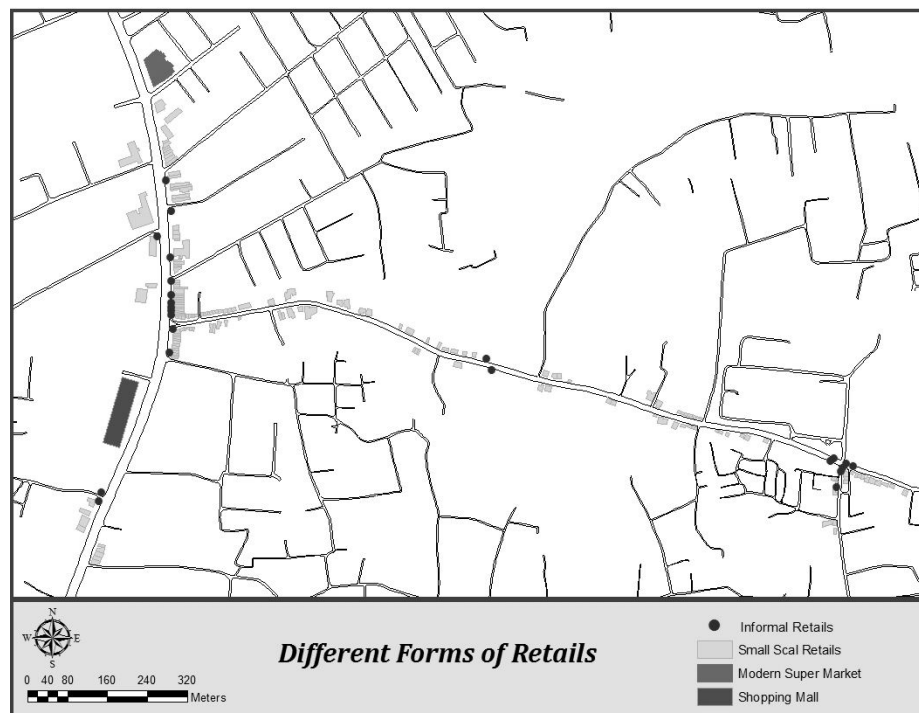


Figure 2: Spatial distribution pattern of retail forms

Table 2: Retail classification

Retail Category	Frequency	%
Food and beverage store	35	19.7
Stationeries & communication	25	14.0
Groceries	24	13.5
Health and personal care stores	20	11.2
Vehicle spare parts	19	10.7
Home furnishings & appliance and household items	17	9.5
Clothing and footwear	9	5.1
Perishables	8	4.5
Gifts, bric-a-bracs and Jewellery	7	3.9
Hardware	5	2.8
Timber and aluminium stores	4	2.2
Others	5	2.8
Total	178	100.0

Floor area of retail shops

Table 3 shows the floor area of traditional street-based retail shops, modern supermarket and modern shopping mall. In the absence of reliable data sources, the retail space data were calculated using Geographical Information Systems (GIS). Several field visits have been conducted to verify the reliability of data. The results show modern shopping centres consume relatively large amount of urban space and they seem to threaten the rich retail mix in the study area. From Table 3 it can be seen that most of the street-based retail stores (87%) appear to be relatively small with the floor space less than 200m² compared with shopping mall and super market. Furthermore, the findings show that the average floor area of street-based shop was 121 m². The minimum and maximum of floor area of these shops were 13m² and 1870m² respectively. It seems that the size of the street-based retail shop is smaller than retail locations in cities in developed countries. For example, one study shows that the average floor space of traditional street-based retail outlet was 250m² in Melbourne and 207m² in Brisbane in 1991-2002 (Goodman & Coiacetto, 2012).

Table 3: Floor area of retail shops

Retail Form	Floor area (metre square, m ²)							
		1-199	200-399	400-599	600-799	800-1000	2500-3000	4500-5000
Traditional street based retail shop	Number	154	15	4	1	2		
	%	87.5	8.5	2.3	0.6	1.1	0	
Modern Supermarket	Number						1	
	%						100	
Shopping mall	Number	0	0	0	0	0		1
	%	0	0	0	0	0		100
Total	Number	154	15	4	1	2	1	1
	%	86.5	8.4	2.2	0.6	1.1	0.5	0.5

Persons employed in retailshops and customers visited per retail location

In the study area, it seems the retail sector generates a number of employments. The field observation data show that a total of 563 were employed in the retail shops. As shown in Table 4, the average person employed per traditional street-based shop was relatively low (2.7) compared to super market (28) and shopping mall (50). This may be due to the small size of street-based shops and the low numbers of customer visits per small retail outlets. This may be also due to a large number of employees distributed throughout many shops in particularly the shopping mall.

In order to get a more accurate picture of customer flows to retail shops in the study are, this study also observed customer visits to all forms of retails in the morning (8am- 9 am), the afternoon (1pm- 2pm) and the evening (5pm- 6pm) on a week day. The results show that more than 12,500 customers visited all types of shops in the study area within these three hours. It seems that the majority of customers (more than 10,000) visited traditional street-based stores. However, the results indicate that a larger number of customers visited the supermarket and the shopping mall in the study area (See Table 5).

Table 4: Persons employed in retail location

Retail Form	Persons employed per retail shop (Mean)	Total Persons employed in retail shops
Traditional street based retail	2.7	485
Modern Supermarket	28	28
Shopping mall	50	50

Table 5: Customers visited per retail location

Retail Form	Number of customers visited per location		
	Morning (8 am-9 am)		
	Mean (At same time)	Maximum	Total customers visited
Traditional street-based shop (n=178)	16	118	2953
Ambulant trader (n= 23)	11	30	259
Modern supermarket (n=1)	300	300	300
Shopping mall (n=1)	310	310	310
	Afternoon (1 pm-2 pm)		
	Mean	Maximum	Sum
Traditional street-based shop (n=178)	19	130	3368
Ambulant trader (n=23)	24	90	563
Modern supermarket (n=1)	178	178	178
Shopping mall (n=1)	230	230	230
	Evening (5 pm-6 pm)		
	Mean	Maximum	Sum
Traditional street-based shop (n=178)	21	118	3799
Ambulant trader (n=23)	18	42	413
Modern Supermarket (n=1)	230	230	230
Shopping mall (n=1)	362	362	362

Longevity of the retail outlets

The field data suggest that the study area has experienced a greater rate of retail change during the last the last 10 years. What is most remarkable when looking at this increase is that the number of traditional street-based shops has increased from 9 to a total of 160 while modern super market and shopping mall have increased by 2 during the same time period, as shown in Table 6. This may be due to the growth of population in the area, and increased pedestrian movements due to growth of service sector activities such as banks and education institutions. It could be also attributed to the initiative of people who are unemployed and live in poverty developing small-scale trades to earn money. These data further suggests that the small street-based retail outlets are the dominant feature in the study area.

Table 6: Age of the retail shops

Retail Form	Change during selected time periods Age category (years)		
	20 years ago	10-19 years	Past 10 years
Traditional street based retail			
N	7	9	160
%	4.0	5.1	90.9
Modern Supermarket			
N	0	0	1
%	0	0	100
Shopping mall			
N	0	0	1
%	0	0	100

Spatial distribution of retail shops

The growth of retailing particularly the street-based traditional shops over the last three decades and how they transform the urban space are better understood through retail location maps.

For this purpose, all forms of retail sites have been mapped out by using field observation data. The maps (Figure 3) show location of all fixed trading sites on main roads over the last three decades. The evidence of fixed trading sites clearly indicates the growth in the number of retail sites associated with the increased number of traditional street-based small retail outlets. It also shows how residential lands on main streets, particularly along the Campus Road, have converted into retail outlets and the dramatic expansion of small retail shops on adjacent sites (Figure 4). It was calculated that about 10000 square metres or 1 hectare of new retail/commercial land has been added to the study area. As the Figure 4 shows below, the sites which have become retail land use after 2002 have been mainly residential land uses before 2002. Furthermore, findings show the gradual increase of relatively large shopping centre (shopping mall and supermarket) and how these two large sites of shopping centres have transformed the urban space.

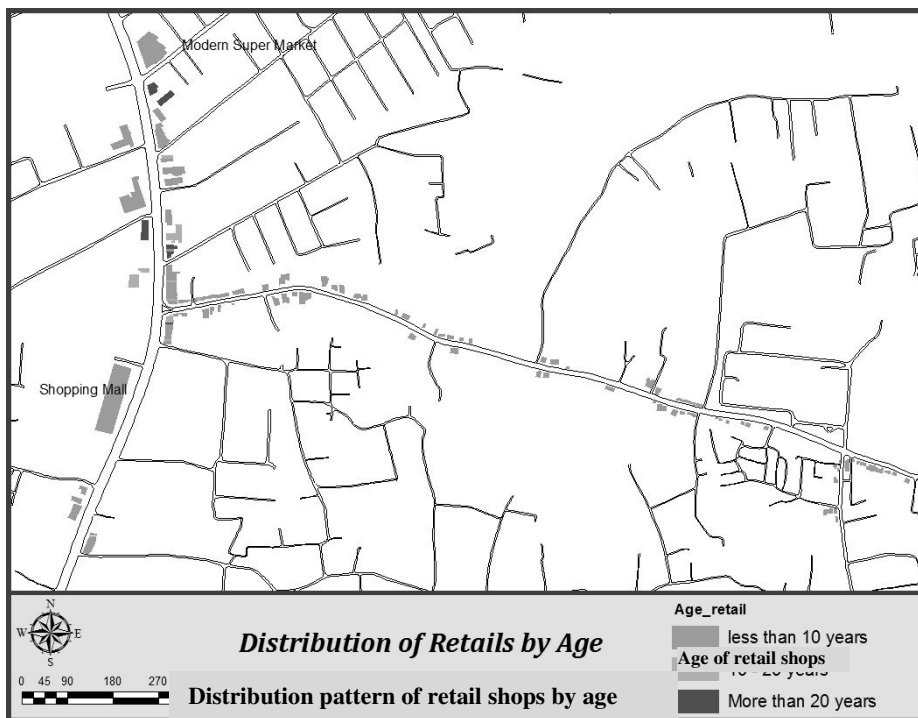


Figure 3: Distribution pattern of retail shops by age



Retail locations before 2002 in Katubedda area



Retail locations after 2002 in Katubedda area

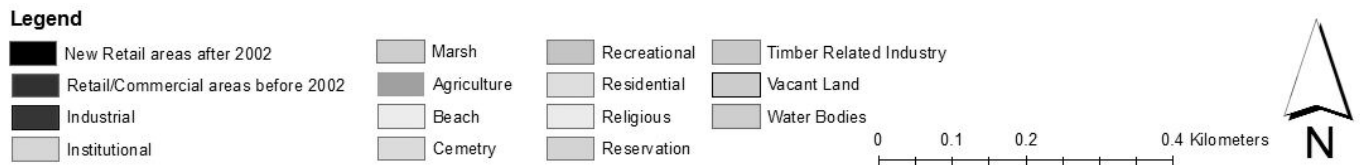


Figure 4: Land use Changes

Discussion

The aim of this research was to investigate different forms of retail provision and to understand to what extent retail development transforms the urban landscape in a rapidly changing urban area in Sri Lanka. The study also carried out a field observation survey to document advantages of the retailing sector as a generator of employment and generator of vibrant urban spaces, a vital part of the everyday urban experience of people in Sri Lanka.

In cities in developing countries, the retail sector, particularly the traditional street-based retail sector, flourishes and contributes a substantial amount to economic growth (Rajkumar & Jacob, 2010). In India, the organized retail sector in 2011 is estimated to be growing at a rate of 15-20 per cent per annum (Global Retail Development Index, 2012). In Sri Lanka, it appears that post-war stability, political stability, unprecedented levels of tourism growth (46 percent in 2010 and 31 percent in 2011) and infrastructure development facilitate the expansion in the retail footprint (Global Retail Development Index, 2012). Although the organized retail sector makes up only about 3 percent in the Gross Domestic Product (GDP), it is expected to grow steadily. Modern supermarkets and hypermarkets continue to grow in city centres. For example, Arpico, a domestic chain of modern supermarkets, increased its number of outlets in different city centres in Sri Lanka from 10 to 31 in 2011 (Global Retail Development Index, 2012).

The findings of the present research highlight that the small street-based retail sector has been growing at an increasing rate during the last two decades and also contributes in generating employment. It appears that the growth of modern supermarkets and shopping malls has been slow; however, it is expected that they will continue to grow and become popular in the future. In that respect, the present study findings support past studies that show the dominance of small retail shops and the steady growth of shopping malls and hypermarkets in cities in developing countries (Bromley, 1998; Duany et al., 2000). Although the present findings reflect a realistic picture of small retail development in urban areas in Sri Lanka, it needs extension to the whole Moratuwa city council area and few more urban areas in order to get a more complete picture of the growth of supermarkets and shopping malls in urban areas in Sri Lanka. Nevertheless, the study area findings show that the area has a rich retail mix which provides a variety of retail options with respect to goods on sale for customers.

The study counted the number of customers who visited each retail shop in the area. From this data, it appears that retailing sector, more particularly; traditional street-based retail sector helps to make the urban street busy and vibrant. Since retail shops operate until late night on weekdays and weekends, this will improve the spatial confidence of pedestrians when using urban spaces at night. Further, this study analyse the floor area of all retail shops in the area and this data reflect that modern markets consume relatively a large floor area in the urban landscape compared to traditional street based retails. This has changed the landscape in the Katubedda area. The development of large-scale market may threaten the existence of small retail outlets in the future in this area. Such development trends will have an effect on the urban experience of people, and thereby the vitality of the area.

This study findings support to compare average floor area size of street based retail shops in cites in developed and developing countries. In contrast to that of the findings of average floor area size of street based traditional retail shops in Melbourne in Australia, the present study results show that the average size of street based retail shops are relatively small in Katubedda area. Furthermore, past research highlights that large shopping malls and modern market stores tend to locate on outskirts in cities in developing and developed countries (Bromley, 1998; Ghani, 2005). However, the present study findings show that large new markets are located along the main roads within close proximity to (within 500m) the urban centre. It appears that these large markets work well with the aid of efficient public transportation system in this area.

The research findings show retail development has negative influence on the other land uses. Haphazard development of retail outlets along the roads and unplanned transformation of residential areas into commercial land uses will cause liveability issues in the existing residential areas as well as causing traffic problems more generally in urban areas. The present study did not study about liveability issues associated with retail sector and it needs to be focused in the future studies. Nevertheless, planning authorities do not seem to be aware of this development. They seem to be unintentionally promoting retail sector expansion along existing residential areas. Since it is the primary responsibility of planning authorities to control and guide the urban development, local planning authorities need to have a consistent, holistic retail development policy to sustain an appropriate mix of retail development as well as other land uses in urban areas.

There has been a dearth of academic publications of systematic survey-based research of transformation of urban spaces and the impacts of retail sector expansion in urban areas in Sri Lanka and more generally in developing countries. Given the already increasing importance of transforming urban spaces due to different formats of retail shops and their associated impacts on other land uses, the retail sector's development in urban areas in Sri Lanka should be studied more systematically with field surveys in order to further analyse residents' perception of retail sector expansion in urban area, consumer satisfaction on existing retail sector, retailers' views ongoing retail sector development in cities, health issues associated with retail shops and infrastructure problems related to the retail sector. These appear to be the important gaps in retail sector studies in cities in developing countries that urgently need addressing in urban policy research.

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Current Approaches for Bid/No Bid Decision Making by the Contracting Organisations in Sri Lanka

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Abstract

Construction bidding is the procedure for submitting comprehensive proposals by bidders for undertaking construction projects. Contractors often procure projects through competitive bidding and the bid/no bid decision making is a key milestone in a project. Though numerous bid/no bid decision-making models have been developed, most of these models have practical and theoretical limitations which limit their applicability in practice. Hence, the ultimate aim of this ongoing research is to propose an appropriate hierarchical framework for bid/no bid decision-making suitable for adoption by Sri Lankan contractors. Before proposing a framework, it is needed to ascertain the current practice of bid/no bid decision making approaches under the Sri Lankan construction scenario with the identification of factors affecting the decision. This research is based on a qualitative approach, which analysed using code-based content analysis, data obtained through semi structured interviews to provide significant findings. The results of the analysis indicate the consequences of the wrong bid/no bid decision making under two worst-case scenarios, viz, 'accepting a wrong bid' and 'rejecting a proper bid'. Furthermore, three common bid/no bid decision making approaches practiced by Sri Lankan contractors and factors that affect bid decision making were identified in order to assist future studies related to the same research.

Keywords: Bid/No Bid Decision, Contract Bidding, Decision-Making Approaches

1.0 Introduction

A construction project is a combination of many processes which interact with each other at different stages (Kiavash, Hazhir & Ali, 2011). Construction bidding is one of those processes, which involves the submission of a comprehensive proposal to undertake or manage a construction project and indicating the probable construction cost (Dagostino & Peterson, 2011). Construction contractors often procure projects through competitive bidding to ensure their continued existence (Wanous, Boussabaine & Lewis, 2003). Since the construction industry is extremely fragmented and competitive, contractors are called upon to deal with various bidding procedures to be in line with a variety of procurement routes available for satisfying a client's construction needs (Ma, 2011). Contract bidding therefore should essentially involve making a strategic decision, such as a bid/no bid decision to ensure the impartiality of the process (Egemen & Mohamed, 2007). Further, Egemen and Mohamed (2007) have stated that this decision should be made giving consideration to the probability of winning the tender and the expected profit margin. The bid decision making is a complex process which depends on numerous factors (Chua & Li, 2000). According to Flanagan and Norman as cited in Passer (2013), project size and value, managerial complexity, regional market conditions, current and projected workload of the tenderer, type of client and type of project are some of the factors affecting to bid /no bid decision. Therefore, every construction company, regardless of its size has its own approach for the bid/ no bid decision making (Garret, 2008).

Lin and Chen (2004) have mentioned the availability of numerous decision making models that can assist contractors to take more informed decisions. However, most of them are quantitative methods which have continued to remain within academic circles due to their inherent practical and theoretical limitations. Hence, contractors without making a systematic approach, rely on their experience and intuition when making bid decisions. However, such practices will not always guarantee consistent outcomes (Wanous, Boussabaine & Lewis, 2000a). The critical assessment of two worst case scenarios i.e. 'accepting a wrong bid' and 'rejecting a proper bid', indicates that proper bid decision making is strategically beneficial for any contracting firm (Bargies & Fortune, 2006). Hence, this study aims at proposing a suitable

approach for bid /no bid decision making of Sri Lankan contractors. The following objectives have been set up as milestones to achieve this aim.

- To identify existing bid/no bid decision making procedures/models
- To examine the importance of the bid/no bid decision with regard to the consequences of a wrong decision
- To recognize the bid/no bid decision making approaches currently practiced by the Sri Lankan Construction industry
- To identify factors to be considered by the contractors when making their bid /no bid decisions

1.1 Scope and limitations

Since this research is an ongoing study, this paper set out the initial layout to develop the hierarchical framework for bid/no bid decision-making by emphasising on identifying local bid/ no bid decision making approaches and the factors should be considered under those approaches. Further, the research is limited to the grade C1 contractors due to their higher familiarity of using systematic approaches than the below graded contractors.

This paper begins with a review of literature on bid/no bid decision making processes followed by the research methodology adopted and the findings of the study and ends up with conclusions and recommendations.

2.0 Overview of construction bidding

2.2 Construction bidding process

Bidding, in general, means the conversion of numbers in a competitive bid after consideration of market factors and risks (Cooke & Williams, 2004). According to Zhu (2008), construction bidding is the procedure of submitting a proposal by a contractor to carry out a construction project at a price mutually agreed with the client. Bidding is the only possible way for a contracting firm to survive within the highly unstructured construction industry and secure tenders and make profits. (Egemen & Mohamed, 2007) Similarly, the survival of a contractor firm strongly depends on as to how successful it can become under different bidding situations and time constraints (Wanous *et al.*, 2003). Further, continuous bidding for suitable projects would reap several benefits to the contractors such as the build-up of its reputation, increase of its income, opportunity that become available to understand the bidding process, improvement of its negotiation skills, etc.

Further, Tang (2004) has identified the construction bidding process under two perspectives, i.e. contractor's perspective and consultant's perspective. Though the bidding process is always initiated by the consultant, this study is in the process related to the contractor. Hence, as indicated in Figure 2.1 below, from the contractor's perspective, bidding is a process which involves a decision to bid and planning and submitting a competitive estimate to secure the work (Lin, Lo & Yan, 2006):



Figure 2.1: Typical phases in bidding process in the perspective of the contractor
Source: Lin *et al.* (2006)

The bidding decision can result in either the success or the failure of a construction contractor (Rodriguez, 2013), since a bidder in competitive bidding will be faced with two seemingly incompatible and contradictory objectives viz., to bid high enough to make a profit and to bid low enough to secure the contract (Tang, 2004). Competitive bidding therefore offers many opportunities under different bidding arrangements.

2.2 Different bidding arrangements

Bidding is considered as a way of obtaining a price from a contractor (Cook, 1991). According to Abu Shaaban (2008), a construction company can either negotiate with the client or use competitive bidding to obtain a contract. Liscum (2010) has classified bidding as practiced in the construction industry, either as public or private where public bidding is a competitive process and private bidding is a price driven process.

According to Drew, Skitmore and Lo (2001) a significant amount of construction work are done through competitive tendering. In competitive bidding, a client invites all contractors to bid for the project and the bid decision making would be at the contractor's discretion (Ma, 2011). As the name implies, incompetent bidding a number of contractors will compete against each other to offer in their view the most favourable bidding price (Cook, 1991). On the other hand, in non-competitive bidding, the client allows a single bidder identified by him to submit a bid and negotiate with him until he and the bidder mutually agree on the amount payable to the latter (Cook, 1991). Moreover, Cook (1991) has stated that the selection of the bidding type depends on the nature of the project and the client's requirements. This study is focused on the bid/no bid decision making procedure as applicable for competitive open bidding among Grade C 1 contractors in Sri Lanka.

3.0 Bid/no bid decision

The Project Management Dictionary (2014) defines the bid/no bid decision as the decision taken to submit or not to submit a proposal in response to an invitation received to bid. A bidding strategy of a construction company relates to two critical decisions that it can make, i.e. the bid/no bid decision and mark up size determination (Ravanshadnia, Rajaie & Abbassian, 2011; Egemen & Mohamad, 2008). However, out of these two decisions bid/no bid decision is more critical than the other as it is the first decision that has to be taken to act as a base for the other decision. (Egemen & Mohamed, 2007).

According to Ravanshadnia, *et al.* (2011) the bid/no bid decision is associated with uncertainty and complexity because of its subjectivity. Bagies and Fortune (2006) have mentioned that the bid/no bid decision will be critical for any firm since its success and existence will strongly depend on the outcome of that one-off decision. They have further stated that the bidding decision made by a firm has a significant influence on its short-term profits and long term performance. Hence, a proper bid/no bid decision is required to prevent an organization from preparing an ineffective proposal and thereby wasting its resources (Lin & Chen, 2004). Moreover, Egemen and Mohamed (2007) have stated that it is not easy to make a proper bid /no bid decision because of the dynamic nature of most of the projects. They have further suggested that there needs to be a concurrent assessment of many factors before arriving at a decision.

3.1 Factors affecting bid /no bid decision

Many scholars in their own studies in the past have identified factors that affect bid decisions. Many have identified the same set of factors and Table 3.1 below tabulates the list of such common factors identified by different researchers in recent years.

Table 3.1: Factors affecting bid/no bid decision

Source	Factors affecting bid/no bid decision
Bargies and Fortune (2006)	<ul style="list-style-type: none"> • Project characteristics • Business benefits • Client characteristics • Contract • Project finance • Company characteristics • Firms' previous experience • Bidding situation • Economic situation • Competition
Egemen and Mohamed (2007)	<ul style="list-style-type: none"> • Need for work • Strength of firm • Project conditions contributing to profitability • Risks of the project • Competitions • Strategic considerations
Flanagan and Norman (as cited in Wang, 2011)	<ul style="list-style-type: none"> • Project size and value, managerial complexity • Regional market conditions • Current and projected workload of the tenderer • Type of client • Type of project

Since, this research study aims at identifying the bid/no bid decision making procedures practiced by the Sri Lankan construction industry and their drawbacks, it would be helpful to get an idea about all the possible factors that can affect bid decision making. The set of factors identified by Bargies and Fortune (2006) has covered a wide variety of factors that has not been figured out by other scholars. Therefore, it has been taken into further consideration in this study.

3.2 Different approaches for bid/no bid decision making

In practice, bid/no bid decision is made subjectively relying on experience and intuition rather than through a systematic approach (Egemen & Mohamed, 2007). Yet, in the recent past, several studies have been conducted to assist bid/no bid decision making (Lin & Chen, 2004). According to Ravanshadnia, *et al.* (2011) bid decision making can be broadly divided into three models based on their method of justification, (1) probability theory (2) decision analysis and (3) knowledge based expert system. Similarly, Oo, Drew and Lo (2007) have grouped these models into (1) multi-attribute decision models (2) statistical models and (3) artificial intelligence-based models. Since, the classification done by Oo, *et al.* (2007) facilitates a clear cut among bid/no bid decision making procedures that classification has used in this research and the following is provided a brief description of each model.

- Multi attribute decision models

Multiple attribute decision modelling is easy to implement and understand and it focusses on the most important issues using qualitative data (Lin & Chen, 2004). Scholars have derived models based on an Analytic Hierarchy Process (AHP) and a fuzzy linguistic approach in order to subjective analysis (Seydel and Olson, 2000).

AHP is based on a deterministic approach which involves pair wise comparison of criteria effects on bid/ no bid decision and its judgments are expressed in a linguistic scale and each judgment is translated into a numerical point value in order to get the decision (Ravanshadnia, *et al.*, 2011), while Fuzzy approach provides a useful tool to deal with decisions in which the incidents are imprecise and vague (Ravanshadnia, *et al.*, 2011).

- Statistical models

According to Lowe and Parvar (2004). Statistical models basically rely on the probability theory and based on the quantitative data when arriving at the bid/no bid decision.

Parametric model is one of such statistical model which considers several parameters gathered based on the subjective data, analyzes those parameters considering their importance (Wanous, Boussabaine & Lewis, 2000b). Regression approach is another which analyses all the variables relate to bid/no bid decision using statistical tools and identify the relationship between variables (Lowe & Parvar, 2004).

- Artificial Intelligence based models

According to the Wanous *et al.* (2003), Artificial intelligent based models can find solutions in complex situations due to its computational base and most of the time those models were developed with the base of an expert system. Further, Wanous *et al.* (2003) stated that it offers a simple and user friendly tool to assist contractors in considering the most dominant bidding variables and is used to improve the stability of the bid/no bid decision-making process. According to Dias and Weerasinghe (1996) there are different types of ANNs available, i.e. self-learning networks and networks which have to be trained.

However, the main aim of this research is to address the bid/no bid decision making approaches practicing in the Sri Lankan construction industry, the features and characteristics of the aforementioned models have not been described comprehensively. Table 3.2 provides brief details of earlier researches done on the bid/no bid decision making approaches.

Table 3.2: Models developed to make bid/no bid decision

Category	Model
Multi-attribute decision models	A decision-Support system for modelling bid/no-bid decision problem (Ahmad, 1990)
	Multi criteria support for construction bidding (Seydel, & Olson, 2000)
	Multiple criteria decision-making models for competitive bidding (Liu <i>et al.</i> ,2000)
Statistical models	Comparative analysis of pre-bid forecasting of building prices (Gunner, &Skitmore, 1999)
	A parametric approach to modelling bid/no bid decision (Wanous, <i>et al.</i> , 2000; Lowe &Parvar, 2004)
	A logistic regression approach (Lowe &Parvar, 2004)
	A model ascertaining the effects of client and type and size of construction work on a contractor's bidding strategy (Drew <i>et al.</i> , 2001)
Artificial intelligence-based models (new trend)	'BidExpert' is an expert system integrated with a database management program, called 'BidTrack', thatretrieve historical information from past bids submitted by the company and its rivals (AbouRizket <i>et al.</i> , 1993)
	An artificial neural network (ANN) model (Wanous <i>et al.</i> , 2003)
	Artificial Neural Networks for construction bid decisions (Dias &Weerasinghe, 1996)
	A computer program named 'Expert Choice' was developed, utilising AHP. (Abdelrazig, 1995)

3.3 Drawbacks of the established approaches

Although there are many approaches that have been used to assist the contractors in bid decision making, Bagies and Fortune (2006) have stated that some of these approaches are not intended to produce a bid/no bid decision support model and none of them comprehensively identifies bidding factors. Similarly, Egemen and Mohomad (2007) have stated that most of these models remain only as academic exercises and that they do not suit practical situations. A brief description about the drawbacks of the main bid /no bid decision making approaches is described below:

- Multi attribute decision making models:

As highlighted by Lin and Chen (2004), the terms used in these models for evaluating (i.e. high, medium and low) depend on the managerial expertise of the decision-maker. In addition, the computation and comprehensiveness of the conversion of a linguistic term into a weighted average is also a drawback of these approaches (Lin & Chen, 2004).

- Statistical approaches:

According to Wanous *et al.* (2000b), there are loopholes in mathematical bidding models such as the reduction of the number of potential users due to their mathematical complexity and the disregard of the objectives of the contractor other than the maximizing of profits. In addition, incompatibility of the assumptions which have been made for the models and unsuitability of the historical data used for model making are two other reasons for failure of the mathematical models which result in uncontrollable impacts on the contractor (Shashas cited in Ma, 2011).

- Artificial intelligent based models:

According to Wanous *et al.* (2003) though the artificial intelligence based models offer benefits compared to other traditional models, they have their own interpretation difficulties.

Since all of the above approaches have their own merits and demerits, it is advisable to use a combination of these approaches since the application of only one method can result in a wrong decision leading to many adverse consequences.

3.4 Research gap: Need for a proper bid/ no bid decision making approach

According to Bagies and Fortune (2006), the bid/no bid decision has been given less attention when compared with other factors related to bidding. Though there have been many studies done to develop bid decision making, many models have been confined only to academic circles and are not suitable to be applied in practice (Wanous *et al.*, 2000). However, Lowe and Parvar (2004) and Egemen and Mohamed (2007) have agreed that a systematic model would be

beneficial for contractors to improve their decision making, increase their productivity and achieve their business objectives.

According to ICRA Lanka (2011), the construction industry in post-conflict Sri Lanka is on an upward trend. This has prevented experienced contractors from idling while attracting new entrants to the industry (ICRA, 2011). However, even with all those opportunities available, a contractor will still be unable to select a project in an ad hoc manner as it can affect his profitability. Thus, there should be a proper selection procedure for a project. In making use of an available opportunity, a proper bid/no bid decision will play an important role. Further, in the Sri Lankan context, the bid/no bid decision will be critical, as there is only limited research available on this subject. Moreover, contractors lack adequate knowledge to identify the correct bid/no bid decision making process compelling them subsequently to engage in malpractices. Therefore, there is an urgent need for a research on bid /no bid decision making in order to identify a procedure that is applicable to bid/no bid decision making in the construction industry in Sri Lanka.

4.0 Methodology

An extensive literature review was carried out to identify the importance of bid/no bid decision and bid/no bid decision making procedures introduced by the previous researchers. Then the research gap in the existing literature was elaborated, since the literature has not facilitated the identification of the procedures practiced under the local context. The study then carried out on a qualitative approach consisting of semi-structured interviews conducted in two parts. The first part of the interview survey (Interview Part I) was conducted among three local industry experts. This preliminary survey identified the importance of the bid/no bid decision in terms of the impacts a wrong decision can have on the company as well as on its Quantity Surveyor and also the current bid/no bid decision-making approaches practiced by Sri Lankan contractors. With the intention of carrying out the research further, a set of detailed interviews (Interview Part II) followed by Interview Part I was conducted to identify the using pattern of the identified local approaches and the factors considered in the bid/no bid decision making procedures currently practiced by the Sri Lankan construction industry. The profiles of the interviewees of Interview Part I and Part II are shown in Table 4.1

Table 4.1: Respondents' profiles – Interviews Part I and Part II

Code	ICTAD grade	Designation	Experience
Interview Part I			
R-101	C1	Assistant General Manager (Estimation & Contracts)	07 years
R-102	C1	Manager Contracts	>30 years
R-103	C1	Chief Quantity Surveyor	07 years
Interview Part II			
R-201	C1	Manager Contracts	30 years
R-202	C1	Chief Quantity Surveyor	07 years
R-203	C1	Senior Quantity Surveyor	15 years
R-204	C1	Manager Contract Administration and	16 years
R-205	C1	General Manager (Designs and Projects)	36 years
R-206	C1	Quantity Surveyor	10 years
R-207	C1	General Manager-Construction	20 years
R-208	C1	Financial Controller	35 years
R-209	C1	Quantity Surveyor	08 years
R-210	C1	Senior Estimator	07 years

Miles and Huberman (1994) distinguished three iterative processes in the qualitative data analysis as, Data reduction, Data display and Conclusion. Thus, data display will be illustrated using the content analysis in this study. Content analysis is a systematic, replicable technique for compressing many words of text into fewer content categories based on explicit rules of coding (Flick, 2006). Code-based content analysis was used in this study to capture significant findings from the interview transcripts. Major themes and sub themes were formulated in accordance with the objectives and the coding structure was developed accordingly. The QSR. NVivo 2010 computer software was used to simplify the work relating to content analysis. Finally, the conclusions of the research were arrived at by harmonizing all findings of the research.

5.0 Research findings and analysis

The results of Interview Part I indicated the importance of the bid /no bid decision with regard to the consequences of wrong decisions and identified the current bid /no bid decision making approaches practiced by the Sri Lankan Construction industry.

5.1 Importance of the bid/no bid decision

As already mentioned, the importance of the bid/no bid decision was examined first and the summarised findings are illustrated in Figure 5.1.

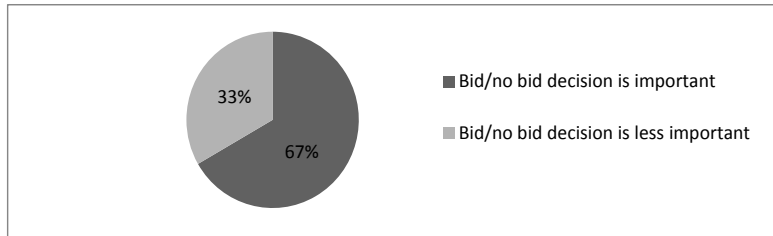


Figure 5.1 Importance of the bid/no bid decision

According to the above analysis of interview data, 67% of the expert interviewees believed that the bid/no bid decision is significant to contractors in the construction sector. Furthermore, R102 and R103 clearly mentioned that the bid/no bid decision and the decision making process crucially affect the operational activities as well as the long term existence of a company. However, according to R101, the bid/no bid decision is not that important to Sri Lankan contractors because of the long-time available from the time of the initial decision for them to submit the proposal during which time the final decision as to whether to proceed with the bidding process or to refrain from bidding will be taken. R101 extended his justification stating that *'bidding decision itself does not carry much risk because bidding does not mean agreeing to undertake the project as such since it is only making an offer'*. On the other hand, as per the majority view, R101 agreed that on some occasions, the bidding decision becomes important and risky because of the nature of the project concerned.

5.2 Impacts of the wrong bid/no bid decision

According to the three experts, it is the company and not its employees that will get affected by a wrong bid/no bid decision. Figure 5.2 shows the coding structure of the consequences of the wrong bid /no bid decision resulting from either accepting a wrong bid or rejecting a worthy bid. The effects on the company and the Quantity Surveyor have been separately taken into account.

Name	R101	R102	R103
Impacts of the wrong bid no bid decision to the company			
Accepting a wrong bid			
Bad mark to the company name	✓	✓	✓
Expected profit will reduce and have to cover it from another project	✓	✓	✓
Financial issues during construction	✓	✓	✓
Have to agree some unfair conditions of the client	✓	-	✓
Issues which can be led to the arbitration	✓	-	✓
Loss of future opportunities due to the problems in accepted wrong bid	-	-	✓
Opportunity cost	-	-	✓
Recourse wasting	-	-	✓
Time wasting	-	-	✓
Rejecting a proper bid			
Create opportunity for competitors due to the less relationship with the client	✓	✓	✓
Loss of chances to be specialized in one field	✓	✓	-
Loss of future jobs with same client	-	-	✓
Loss of good opportunity to make profits	-	-	✓
Resource idling can be happened since not accepting the project at right time	-	-	✓
Impacts of the wrong bid no bid decision to the Quantity Surveyor			
Bad mark to the professional carrier	✓	✓	✓
Less promotions and increments	✓	-	✓

Figure 5.2: Impacts of the wrong bid no bid decisions

It is commonly agreed that, accepting a wrong bid would result in waste of time and resources as well as affecting the company's well-being. Furthermore, the respondents have identified several direct financial consequences of a wrong bid decision, such as cash flow difficulties encountered during construction, loss of profits etc. R101 also mentioned that *'if we undertake a wrong project, at times it can create problems that will be difficult to get rid of'*. R102 stated that once a contractor becomes the successful bidder, he will have to agree to certain unfair terms and conditions which will later on make him to regret his decision to bid.

On the other hand, if the contractor rejects a proper bid, its main impact on him would be the loss of the opportunity to make a good profit and loss of future opportunities for bidding. Furthermore, R102 mentioned that if the project is a continuous project or a follow up of a previous project, the client would always prefer to work with the same contractor and hence a contractor who has not made an offer for the first project may not get invited to bid for the second project. According to R103, the decision of a contractor to not to bid for a good project, will indirectly provide an opportunity for his competitors to increase their market share of the industry.

Moreover, not only the company, but also its professionally qualified employees who were involved in the bid decision making can be affected through a wrong decision. According to R103, in Sri Lanka, the responsibility of making decisions rests with the top management. The role of a Quantity Surveyor would be only to provide the information required to make the decision., R103 thus stated that *'If the Quantity Surveyor has provided false information then it will affect his promotions and increments and may even finally lead to the termination of his services'*.

According to the analysis of the impacts caused by wrong decisions, it is quite clear that making a correct bid /no bid decision is important for any contractors' organisation and its professionally qualified employees who are involved in taking the bidding decision.

5.3 Bid/no bid decision making approaches practiced in Sri Lanka

It is commonly agreed that there are procedures to be followed by a contractor before he makes a bid/no bid decision. However, R101 mentioned that mathematical or theoretical bid/no bid decision approaches mentioned in Sub Section 3.2, are not practiced in Sri Lanka Through Interview Part I, four existing bid/no bid decision making approaches in the Sri Lankan construction industry were identified which are summarised in Table 5.1 below:

Table 5.1: Bid/no bid decision making approaches

R103	R103	R102	R101
Approach 'A'	Approach 'B'	Approach 'C'	Approach 'D'
<ul style="list-style-type: none"> • Examine the tender notice • Consider the Client's details and past experience to make the bid /no bid decision 	<ul style="list-style-type: none"> • Examine the tender notice • Consider basic factors mentioned in the tender notice and decide on purchasing the bidding document • Consider other factors also seriously • Prepare a tender check list • Prepare a major quantity list • Calculate the floor area of the project from the drawings provided and prepare a preliminary budget for the project • Submit all these documents to the top management for the bid/no bid decision 	<ul style="list-style-type: none"> • Examine the tender notice • Make contacts with the party issuing the tender document • Refer the document without purchasing • Consider deeply all factors affecting the decision • Prepare a report, including all the information and hand it over to the management • Senior Managers, discuss and make the decision • If the decision is 'yes' confirm with the employer and purchase the bidding document 	<ul style="list-style-type: none"> • Examine the tender notice • Purchase the tender document • Prepare the project information list by referring to the tender notice and tender document • Hand over that list to the top management to make the final decision • Consider in detail the relevant factors affecting the decision by conducting meetings with responsible personnel • Get the decision and work on pricing

Among the findings, three approaches (Approaches A, B and C) were taken into the consideration and approach D has disregarded due to the similar methodological arrangement as approach B. Further, according to the findings of the interview part II it was found that most of the C1 contractors are using Approach 'B' for bid/no bid decision making. Thus, the outcome of this ongoing research is the selection of Approach 'B' as the basis for developing a bid/no bid decision making approach suitable for Sri Lanka.

5.4 Factors affecting the bid/no bid decision

Factors affecting the bid/no bid decision have been previously identified in Sub Section 3.1 through a comprehensive literature analysis. Since those factors relate to the international construction industry, the researchers decided on identifying factors which affect the bid/no bid decision in the local construction industry. The conclusions derived from the analysis of Interview Part II are tabulated in Table 5.2 which illustrates the main factors and sub factors affecting the bid/no bid decisions in Sri Lanka, This Table also indicates the respective sources of information.

Ten main factors have been identified and project characteristics, project finance and business benefits have been identified as the main factors, by all the respondents and therefore special attention needs to be paid for these sub factors. Client's characteristics is another factor to be considered. However, R208 argued that a contractor should be capable enough to deal with any type of client to earn profits from his business independent of the client's characteristics. Further, the details of the contract need to be critically considered before making the bid/no bid decision. R203 stated that *'major conditions that adversely affect the contractor should be considered'*. According to the respondents, the contractor's 'company characteristics' is another factor to be considered. R207 mentioned that *'the contractor should be aware of his competencies'*. Some respondents were not interested in the firm's previous experience. R203 stated that *'if we can comply with the requirements we do not worry about past experience'*. Similarly, R208 expressed that *'without experience also we do projects'*. R205 explained, saying *'Sometimes we go for new areas as we want to acquire experience'*. The competition drew most of the attention as a factor that needs consideration and also as a factor that can be disregarded. R202 revealed its importance citing an actual situation where a competitor first tried hard to get a project, regardless of its feasibility later deciding not to bid. On the other hand, some respondents argued that competition does not affect all their decisions to bid. According to R203, *'competition is there in any project. So we don't change our decision because of competition'*.

According to the respondents, the environmental effect and the country's economic situation are the two least significant factors to be considered when making the bid/no bid decision. R207 stated that changes in economic variables are considered as a general factor common to the entire industry and that therefore it will not require special attention in bid decision making.

In order to make a bid/no bid decision, contractors obtain information on the project from the tender notice, bidding document, past experience and past records and through discussions with the management.

Table 5.2 Factors and sub factors to be considered when taking the bid/no bid decision

Main Factor	Sub factors	Sources of information
Project Characteristics	Project type, Nature of the project, Location of the project, Project duration, Contract amount Scope and extensity of the project →	By referring to the tender notice By referring to the bidding document
Business benefits	Profitability of the project, Availability of future opportunities, Use of existing resources	Through a discussion with the management
Project finance	Nature of the funding agency	By referring to the tender notice
Client's characteristics	Nature of the client, Capacity of the client, Present relationship with the client	Through past experience
Contract	Particular conditions of the contract related to payment terms, method of measurement, variation procedures, major clauses such as the arbitration clause, BOQ and preamble notes	By referring to the bidding document
Contractor's company characteristics	Contractor's capacity, Resource availability, Distance between one's own plants and the project site, Ongoing projects Suppliers, Company turnover and credit line →	Through a discussion with the management Using past records
Firm's previous experience	Similar to past experience	Through past experience and records
Competition	Competitors' competitive level, Competitors' nature of bidding	Through past experience and records – Specially from the records of previous pre bid meetings
Economic situation of the country	Bank interest rates, Exchange rates	Through past records
Environmental effects	Weather conditions, Impact to the environment	Through past experience and records

5.0 Conclusions and recommendations

The ultimate aim of this research is to propose a practical bid/no bid decision making approach suitable for Sri Lankan contractors by filling the research gap. In order to achieve this aim, six objectives were formed and this paper has discussed four of them. According to literature findings, multi-attribute decision models, statistical models and artificial intelligence-based models are the models that have been previously identified. Moreover, these literature findings have revealed that most of these approaches are useful only for academic purposes and not for use by the industry.

Consequently, the importance of the bid/no bid decision was identified in relation to the consequences that a wrong decision can have. Basically, by deciding to not to bid for a project, a contractor could lose a good opportunity to make profits and bidding for an inappropriate project can make him incur huge losses. Out of the three bid/no bid decision making approaches that are being practiced in Sri Lanka (Refer Table 5.1), Approach 'B' is found to be common. The literature synthesis and opinions from the Interview Part II have highlighted ten main factors and a set of sub factors for each such main factor to be considered when making the bid/no bid decision (Refer Table 5.2). In summary, the findings have revealed that although there is a specific approach that can be followed when making the bid/no bid decision, the uniqueness of the construction project concerned will ultimately govern the suitability of that particular approach to the project concerned.

Finally, the study recommends certain steps that can be taken to ensure the success of bid/no bid decision making. Firstly, it is recommended to consider as much as possible all relevant factors when deciding to bid for a project. The more the number of factors that are considered, the more rational will be the decision made. Moreover, when considering these factors, it would be beneficial to have a computerized database containing all past details related to the relevant projects in order to make the process easier. Further, the establishment of a company's own strategy can also be useful in making a correct bid/no bid decision. Having a proper benchmark to filter the bid opportunities would result in quick decision making. Furthermore, it is recommended to have at least one person with adequate knowledge, skills, and experience in the management to take the decision for bidding based on the information provided by the Quantity Surveyor.

Further research

Since this research is an ongoing study, it will be extended to identify the drawbacks of the existing bid/no bid decision making approaches, suggestions to enhance those approaches and to develop a suitable bid/no bid decision making approach for Grade C1 contractors in Sri Lanka. Furthermore, this research can also be focussed on exploring the decision making from the consultant's perspective as well, i.e. whether to be a consultant for a project or not.

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Under-Reporting of Construction Accidents in Sri Lanka

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Abstract

Generally the work environment in the construction industry is more hazardous than in other industries, mainly due to the potential nature for serious accidents and health hazards by heavy use of large equipment, dangerous tools, and hazardous materials. Thus, the number of annual construction accidents are reported high and among them 50-60 are fatal. Moreover, these numbers are under reported and hence the actual number of construction accidents could be several times higher than the reported. Hence, this research attempts to investigate the most significant reasons behind underreported construction accidents and identify the loopholes of the existing reporting systems to recommend efficient mechanisms for occupational accident recording in construction industry.

Accordingly, the research problem was approached through a pre study survey and an expert survey which followed by semi structured interviews. Various stakeholders including management, technical staff and workers in construction sites were interviewed.

The findings revealed that safety representatives of most of the construction organizations reluctant to report to the Labour Department through the district factory inspecting engineer when incidents occur, due to unawareness of legal provisions and burden of paper work. Moreover, lack of knowledge, awareness, systems, management commitments and other facilities exaggerated the situation. Additionally, a strong leadership towards inculcating occupational safety and health was identified as a deliberating need. Therefore, the study propose to appoint qualified safety representatives for each construction site of construction organisations, continuous monitoring of following up the legal provision on notification of accidents, introduction of a prescribed information sheet for all organisations who are involved in a case of an industrial accident and after an accident or development of an online portal and increase the awareness programmes on importance of maintaining records and reporting of industrial accidents.

Keywords: *Construction Accidents, Accident Reporting, Construction Industry, Construction Workers.*

1.0 Introduction

Construction sites are rapidly changing environments with lots of heavy equipment, machinery and large vehicles. Therefore, construction sector has an accident rate much higher than the average in other sectors of economic activity (Pellicer, et al, 2008). Accidents in construction workplaces are unplanned and unwanted occurrences involving movement of persons, objects or materials which may result in injury, damage or loss to property or people (Hosseinian & Torghabeh, 2012). Construction accidents are caused by many factors, including work methods, site conditions, worker failure to use safety equipment, and a lack of proper worker training. Further injuries and deaths commonly involve falls, explosions, burns, electrocution, exposure to asbestos and toxic chemicals, and asphyxiation.

Data accuracy is extremely important for occupational safety and health surveillance, and this is especially true for an industry with an extremely mobile workforce like construction (Fosbroke et al, 1997). Accurate data are essential to implement new data collection initiatives to track the safety and health impacts of emerging technologies, identify the most effective and efficient intervention programs and support the development and diffusion of those programs throughout the industry. In addition, accurate data provides the basis for policy-making and resource distribution (Walter, 2011).

As mentioned above when compared with other industries, it is rendered that the construction industry is the most vulnerable with a reported number of annual accidents; in-between 750-900 (Amarasinghe, 2011). Among them 50-60 were fatal (Amarasinghe, 2011). Further, this annual figure represented a more than 30 percent of accidents which was

about 13 times higher than in the other industries (Rameezdeen, et al., 2003; De Silva and Wimalaratne, 2012). However, these statistics have not disclosed the real situation, as only less than 60percent of accidents are reported (Amarasinghe2011).Therefore, it is clear that, in Sri Lanka the underreporting of construction accidents rate is high. There are many reasons contribute for the underreporting of accidents. Among them, International Labour Organization (ILO) shows the limited coverage of reporting procedures as one of the major reasons (ILO, 1996). Accordingly, this research paper aims at identifying the loopholes of the existing reporting systems to recommend efficient mechanisms for occupational accident recording in construction industry

2.0 Profile of construction accidents

In the construction industry, at least 60,000 people face fatal accidents every year and many hundreds of thousands more suffer from serious injuries (ILO, 2003). Based on the severity, Accidents can be divide in to two, as fatal and non-fatal (Rameezdeen et al, 2003). The number of fatal accidents in the Sri Lankan construction industry is significantly high compared to other industries and it is the largest contributor to fatal accidents followed by mining and quarrying. In Sri Lanka accident rate in construction sites is higher when compared with the other industries (Rameezdeen et al, 2003)

According to the available information at the Industrial Safety Division of Labour department of Sri Lanka, the statistics of fatal and non fatal accident reports are shown as follows.

Table 1: Profile of construction accidents

Year		2009	2010	2011	2012
Construction & All Other Industries	Fatal	76	64	60	80
	Non-Fatal	1449	1456	1313	1319
	Total	1525	1520	1373	1399

However, ILO (2003) reported that in most of the countries, only less than 20 per cent of construction accidents are reported. That is common to Sri Lanka too and according to Amarasinghe (2009) only less than 60% of accidents are reported and therefore, actual figures are likely to be even higher.

3.0 Construction accident reporting procedures

Many incidents have occurred because organisations have failed to learn from lessons of the past. This means that there is room for improvement in the way organisations analyse incidents, generate measures to remedy identified weaknesses and prevent reoccurrence (Drupsteen, Groeneweg & Zwetsloot, 2013).Therefore there must be a process put in place to report accidents, incidents or near misses for immediate action and to help track causes. The Department of Industrial Relations, State of California trots out the importance of record keeping of accidents at work(Department of Industrial Relations, State of California, 2005). It reveals that records of accidents, work-related injuries, illnesses and property losses serve as a valuable purpose which affords an efficient means to review the current safety and health activities for better control of operations, and to plan future improvements (Department of Industrial Relations, State of California, 2005). Oregon State University (2009) states that accident records supply information to identify trends to help control conditions and acts that contribute to accidents and managers can use them as an indicator of the financial impact of unsafe behaviour and the need for loss control efforts and information can be combined with medical and disability cost figures to reflect the direct cost of occupational accidents. Further, Health and Safety Authority, Dublin (2006) says keeping records will help safety representatives to check whether remedial measures have been implemented and to monitor the effectiveness of such measures.

The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995, UK, as cited in Scottish Centre for Healthy Working Lives (2014) shows that with the information provided through recording and reporting, the enforcing authorities are able to help and provide advice on how to reduce injury, and ill health in the workplace. Such

surveillance data can also be used to put forward an evidence-based rationale for the introduction of new legislation and/or guidance.

The organization needs to identify what needs to be reported, to whom it is to be reported, and how to report it, then put this process into a written procedure. For example in America any accident, incident, or near miss no matter how slight the injury or damage, must be reported to the department supervisor immediately for appropriate action. The supervisor is responsible for taking appropriate follow-up action, including getting medical attention for the injured, completing an investigation report and recommending or implementing appropriate corrective actions.

According to Health and Safety Executive (2013) in United Kingdom accidents and incidents of work related ill-health must be recorded in the official site accident book B1510. Accidents and incidents of ill health which result in an absence from work of more than three days must be reported on form F2508 or F2508A (all obtainable from The Stationery Office). These documents are held in the company office or by the senior company representative on site who may designate a responsible person to receive accident reports and make the necessary entries. Staff must be made aware of the requirement to report all accidents at induction. Where the company is a sub-contractor all accidents must be reported to the principal contractor and recorded in his official accident book. The senior representative should make this report on site.

Moreover, under the Factories Ordinance of Sri Lanka, it is compulsory for all factories to report all occupational accidents and injuries caused to workers and if it causes loss of three days, to the Labour Department. Further, all organizations are required to send a report of accidents time to time. However, this is not acclaimed by all organizations due to many reasons.

4.0 Construction accident underreporting and reasons for underreporting

There is convincing evidence that occupational injury and illness rates substantially underestimate the true magnitude of injury and illness in the construction industry. As mentioned above, only less than 20 per cent of construction accidents are reported in most of the countries (ILO, 2003). In Sri Lanka one of the Labour Department's key challenges is lack of reporting of workplace injuries to them (SundayTimes, 06th October 2013).

The underreporting has mainly originated due to lack of awareness of legal reporting requirements, penalties for poor record keeping infrequently levied on firms, and burden of completing the relevant paperwork posing to firms etc. (Lim, 2007). Therefore, it is important to identify a strong mechanism to mitigate the issues on construction accident reporting in Sri Lanka.

5.0 Research methodology

Comprehensive literature review has been carried out in order to observe existing literature on construction accident reporting procedures and reasons for underreporting. A pre study survey was carried out to document the existing accident reporting procedure used in Sri Lanka. Further an expert survey was carried out to validate the documented reporting procedure and to explore its prevailing gaps. Ten experts who are expertized in the area of occupational safety and health were selected for this task and in-depth interviews were conducted. The professional experience of these experts were ranged from ten years to over twenty five years and hold managerial level positions in the industry. Semi-structured interviews were conducted and interview guidelines were prepared prior to the data collection. The design of the interview guidelines was done in accordance to capture the required data to analyse the research problem. The questions of the interview guidelines were developed based on the objectives of the study. While interviewing, note taking and tape recording were done to maintain the accuracy of data collection and avoid losing data as it is impossible to note down everything during the interview. The interviewees' experiences were ranged from 1 to twenty five years. Further four most experienced experts were again interviewed to identify enhancing strategies to proposed recommendations to address the shortfalls in the existing construction accidents reporting system. The collected data were analysed using the content analysis technique.

6.0 Findings

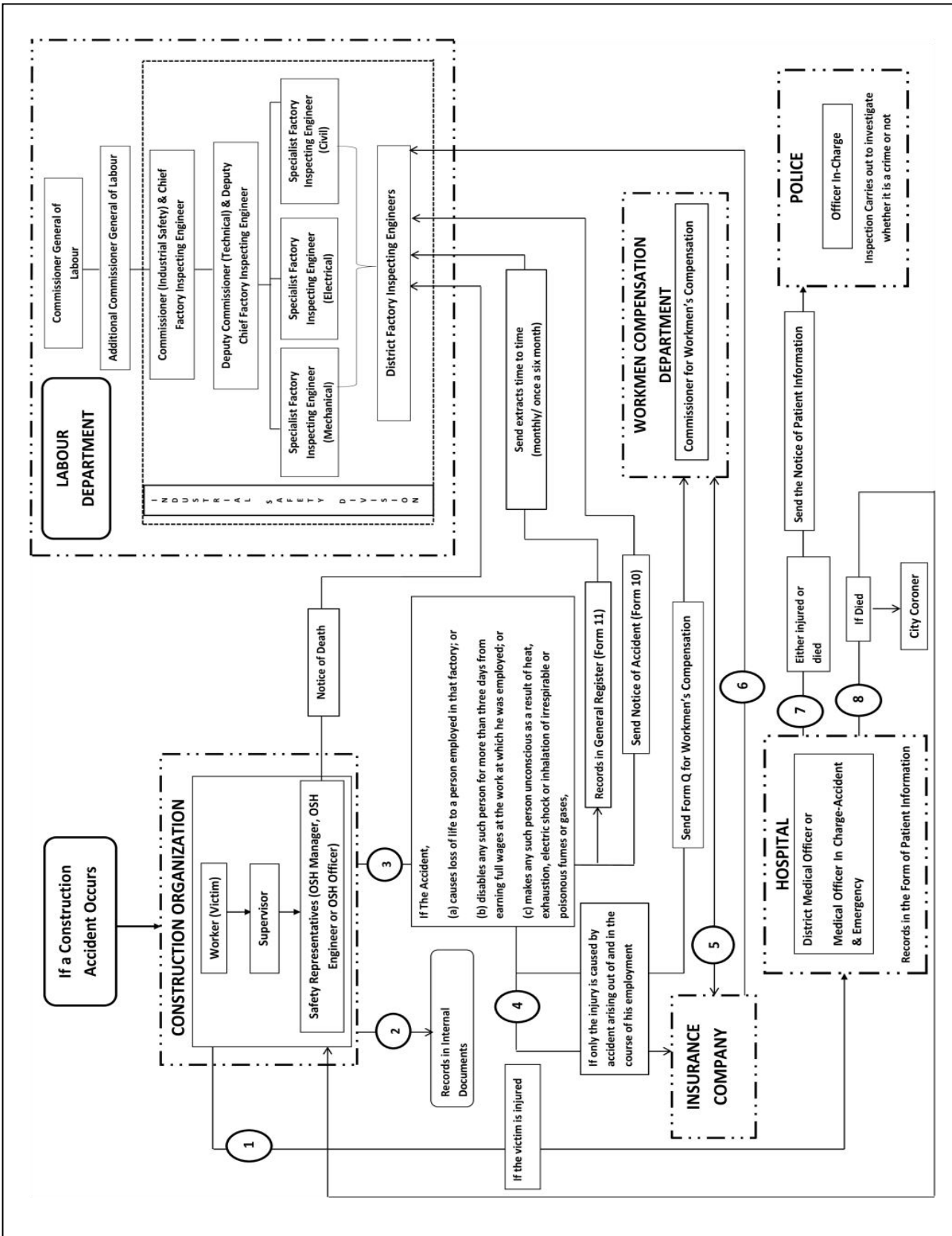
6.1 Existing reporting system of construction accidents

In the existing reporting procedure (Figure 1), if an accident arises in a construction site, the flow of reporting procedure from the workplace to the Department of Labour can be demonstrated and depicted as follows:

- 1) If there is a victim who suffered from an injury, hospitalisation of him/her immediately relies with the safety representatives of the site.
- 2) Immediately after the hospitalisation, the records of the accident should be kept in internal documents of the workplace. Keeping internal records of accidents will help safety representatives to develop prompt arrangements to prevent recurrence of similar kind of accidents and to monitor the effectiveness of such measures. Therefore, internal records are maintained as an accident prevention strategy of most construction organisations.
- 3) The Section 61 (Notification of Accidents) of Factories Ordinance No. 45 of 1942, as last amended by the Factories Amendment Law No. 12 of 1976, describes that, “where any accident occurs in a factory (i.e. in a workplace) which (a) causes loss of life to a person employed in that factory; or (b) disables any such person for more than three days from earning full wages at the work at which he was employed; or (c) makes any such person unconscious as a result of heat, exhaustion, electric shock or inhalation of irrespirable or poisonous fumes or gases, etc., written notice of the accident, in such form and accompanied by such particulars as may be prescribed, shall forthwith be sent by the occupier or manager or the superintendent (in the case of an estate factory) to the District Factory Inspecting Engineer (DFIE)” who is appointed for the respective district.

Accordingly, if an accident categories under one of the above conditions, the employer is liable to send the notice of accident via “Form 10” to the DFIE who is appointed for that particular district. Further, the Section 92(01) of same ordinance prescribes that a “general register” known as “Form 11” should be maintained to record every accident which reported with Form 10. Further a copy of this general register is required to send to the DFIE once in six months.

- 4) If the injury is caused to the workman while he is working in the course of his employment and if it is resulted in the total or partial disablement of the workman for a period exceeding three days, only then the commissioner for workmen’s compensation is informed. (Workmen Compensation Ordinances Nos.19 of 1934). The commissioner for workmen’s compensation should be informed via “Form Q”. In addition to the Form Q, the insurance company is informed, when the organization claims the insurance coverage.
- 5) When a victim is made an insurance claim, the insurance company and the commissioner for workmen’s compensation work closely in order to release the compensation by the insurance company.
- 6) The insurance company is further, bound to provide information of such construction accidents to the Department of Labour.
- 7) If the victim is hospitalised, it is the medical officer’s responsibility to keep records of the patient in the hospital itself and inform the police post of the hospital or nearest police station via a note. Afterwards, the police can start their investigations on the incident.
- 8) The section 61 of the factories Ordinance further describes that “where any accident causing disablement is notified, and after notification thereof results in the death of the person disabled, notice in writing of the death shall be sent to the DFIE by the occupier or manager or the superintendent (in the case of an estate factory) as soon as the death comes to his knowledge”. Accordingly, when the death comes to the employer’s knowledge, DFIE is informed by the employer via a “notice of death”, and when the city coroner is informed by the hospital, the post-mortem is carried out and report will be provided.



6.2 Loopholes in existing construction accidents reporting

The main role of reporting a construction accident lies with the particular construction site. Therefore there should be a systematic approach for reporting and recording of accidents within the organisational/site level. However lack of knowledge, awareness, systems, management commitments, facilities and leadership have caused for the unavailability of a systematic reporting and recording system at this level.

Moreover, due to the inattention, lack of awareness of legal reporting requirements and burden of completing paperwork, most of the safety representatives of the sites and workers do not persuade to report accidents occurred in the sites via notice of accident form (Form 10) to the respective DFIEs. They consider that involvement of the department of labour would create additional distress to them. Further, it was revealed unavailability of a stringent monitoring procedure for following up the law has need of reporting. However, the construction organisations who have already obtained and who are being implementing OSHAS 18001, track this practice as it has been mandated by OSHAS 18001.

As per the Factories Ordinance No. 45 of 1942, it for all factories to report accidents and injuries caused to a worker if the worker is absent for three working days due to an OSH incident. Therefore, the accidents that categorise under “less than three working days from earning full wages at the work” are not reported to any authorized body as there is no legal requirement in the law. However, most of the organisations maintain internal documents for recording of all type of these accidents including “near misses” as a strategy to prevent recurrence of same incident.

6.2 Recommendations

6.2.1 Employing qualified safety representatives for construction organisations

Employing qualified safety representatives is essential in construction organizations/sites to enhance safety management to and thus to eliminate the first two gaps in the reporting procedure. Safety representatives can be Health, Safety and Environment (HSE) officers, Occupational, Safety & Health (OSH) Engineers or OSH Managers. In Sri Lanka, basic qualifications of safety representatives are not defined and therefore, in most of the construction sites, not properly qualified officers are engaged. Therefore, it is recommended defining qualifications that should be required to appoint qualified safety representatives. In line with this, sufficient educational programmes should be introduced to produce qualified people in this arena.

6.2.2 Awareness programmes on accident records and reporting

The awareness programmes on safety and health of workers are conducted frequently. However, the awareness programmes on legal provisions and importance of documentation of accidents are not seen as important aspect. It was identified that some of the staff who work as safety representatives even do not aware the legal provisions. Therefore, awareness programmes should be increased in order to have an efficient recording and reporting of the accidents.

6.2.3. Decree to implement the SLS OSHAS 18001 Standard

The Institute for Construction Training and Development (ICTAD) as the governing body of construction industry in Sri Lanka, can decree to implement the SLS OSHAS 18001 for all grades of construction companies in Sri Lanka. SLS OSHAS 18001 is particular on documentation. Therefore, it will lead every construction organisation to document each and every aspect of health and safety of construction sites.

6.2.4. Encourage construction organisations to apply for OSHE excellence award

National Institute of Occupational Safety and Health of Sri Lanka in collaboration with Ministry of Labour and Labour Relations offers awards for organisations who excel in occupational health and safety. This would be a strategic movement to motivate construction organisations to follow OSH guidelines and practices and eventually to fill the gaps in the prevailing under-reporting condition. Further, such a promoted OSH culture will reduce risks of occupational accidents.

6.2.5. Amendments to the existing regulations on OSH

Penalties for the underreported accidents

Even though the Factories Ordinance call for the reporting of construction accidents it does not has any verdict on the result of none reporting of an accident. Therefore with the above mentioned difficulties the safety representatives of the construction sites are not willing to report the accidents occurred. However, if there is any penalty for none reporting then there is an influence to report the accidents by the responsible parties. Therefore introduction of a penalty will support in systematic reporting system.

Certification by Labour department to issue the insurance claim compensation

In the current insurance compensation system some the insurance companies do not request a labour department certificate to issue the insurance claim. However if there is such regulation imposed on all the insurance companies then they will ask for a certification by labour department from the construction companies. This will pressure the construction companies to report major accidents to the labour department.

Regulation to report the accidents that categories under “less than three working days from earning full wages at the work”

It is identified that to have an effective recording it is necessary to record all the accidents in the construction industry. Therefore as the existing law lacks the necessity of reporting accidents in the category of “less than three working days from earning full wages at the work”, the law should be amended with a sentence on necessitating the reporting of all accidents in the construction sites.

7.0 Summary

Effective and efficient accident reporting and recording system for construction industry in Sri Lanka is a deliberate need. Since the accident rate of construction industry is getting high, it is a responsibility of the authorized bodies to working closing together to reduce the situation. Having said that, availability of reliable data of accidents are important. The research makes it clear that there are prevailing gaps in the existing accident reporting procedure, which creates inefficient recording system. As the main role of accidents reporting and recording lies with the construction site it was identified that appointment of qualified safety representatives for each construction site of construction organisations, continuous monitoring of following up the legal provision on notification of accidents, increase the awareness programmes on importance of maintaining records and reporting of industrial accidents, decree to implement the SLS OSHAS 18001 for occupational health and safety management systems and encourage the construction organisations to apply for OSH excellence awards as strategies to mitigate the gaps in existing accident reporting and recording procedure of Sri Lanka. Moreover it is recommended amendments to the existing regulation by adding penalties for non reported accidents, request a certificate by the labour department to issue insurance claim compensations and regulation to report the accidents that categories under “less than three working days from earning full wages at the work”. These proposed strategies will serve on unveiling an efficient and effective recording system for construction industry to enhancing its image of OSH.

8.0 Acknowledgement

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Training and Development Framework to Improve the Maintenance Workers' Productivity in the Sri Lankan Hotel Sector

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Abstract

The hospitality industry and hotels in particular, have witnessed increasing competition for high service quality and customer satisfaction. Sri Lankan hotel industry faces a range of difficulties due to lack of productivity of the maintenance workers. Training and Development (T&D) is one of the foremost part of human resource management which can influence to improve productivity of maintenance workers. Accordingly, the aim of this research is develop a T&D framework to improve the maintenance workers productivity in the hotel industry. Case study was selected as the most suitable research method for this study. The reasons being, the study needed to focus on in-depth decisions and behavioural attitudes of individuals and groups within and between organisations. Case study findings revealed that, organisations conceived a positive impression on the importance of systematic implementation of T&D to improve the productivity of the maintenance staff. However, the organisations found themselves confronted by some barriers on implementing such systematic processes. As a result, the importance of adapting such systematic processes and the benefits they may bring into the organisation remain unidentified by the organisations.

Keywords: Training and Development, Productivity, Maintenance workers

1. Introduction

Hospitality is one of the world's oldest professions, and it continues to be figured by its history. At the same time it is changing quite momentarily in response to changing requirements and expectations of consumers (Crick and Spencer, 2010). Consequently, maintenance of hospitality buildings became difficult and active as the performance of the engineering systems is subjected to insightful user's requirements (Chan *et al.*, 2001). Maintenance performance is generally hard to quantify (Groote, 1995). However, productivity and dependability are significantly dependent upon human factors and this is chiefly apparent in relation to maintainability and maintenance works (Winterton, 1981). Unfortunately, most of the Sri Lankan hotels are facing a range of difficulties due to unskilled maintenance workers.

2. Rationale

Literature on Training and Development (T&D) is comparatively new in the context of hotel sector. Based on case studies conducted by Yang (2010) in Renaissance Shanghai Yuyuan Hotel, China, and Ameer and Hanif (2013) in the hotel sector of the Lahore, Pakistan, employees' perception towards the organisation and the work performance is significantly affected by the training and development. However, Yang's (2010) study reveals that, the expected outcome of the training is not achieved most of the times. Further, Sharma and Choudhary (2011) stated that, due to economic and budgetary constraints the hotels are tempted to cut down training programmes. Abovementioned facts proved that the training and development needs an effective implementation method to achieve its objectives.

Numerous literatures (Ben-Daya *et al.*, 2009; Hooi, 2009; Dowling *et al.*, 1999) discussed the variety of benefits which can be achieved by the organisations and the employees. However organisations are reluctant to conduct T&D programmes due to various reasons such as cost constraints, unavailability of resource persons, lack of commitments of the employees (Sharma and Choudhary, 2011). As a result, the research problem that emerged through this study is the importance given to T&D programmes by the organisations and the maintenance workers are not sufficient enough to achieve the benefits of T&D.

Further, Worker's productivity can be affected by several factors such as unclear instructions, lack of knowledge, delay arrival of materials, lack of equipment, working environment, frequent damage of equipment, glare, ergonomic issues, argument with workers, lack of supervision (Attar et al., 2012; Yates, 2014). Based on a research rating conducted by Mahamid et al., (2013) the most important factor affecting general labour productivity is lack of labour experience. Researchers suggested training and motivation as a solution to improve labour experience (Attar et al., 2012, Mahamid et al., 2013).

Training and Development (T&D) is one of the processes of developing and unleashing capabilities of the Human Resources which can influence to improve productivity of maintenance workers (Swanson, 2001). Therefore, this study aims to develop a T&D framework to improve the productivity of the maintenance workers of the hotel sector by providing a suitable process to conduct the T&D programmes.

3. Literature review

3.1 Maintenance of hotel buildings

Maintenance is the effort in connection with different technical and administrative actions to keep a physical asset, or restore it to a condition where it can perform a required function (Chan *et al.*, 2001). The importance of maintenance in the hotels is critical as they are active, complex and costly buildings to function. There are different uses of spaces that have unusual schedules and consumption, comprising guest rooms, restaurants, health club, function rooms, retail stores, laundry, swimming pool, etc. in hotels (Chan *et al.*, 2001). The process of Maintenance Management in a hotel is often a shared responsibility, although it may be allocated directly to the maintenance department (Lockyer, 2013). Lack of maintenance can very quickly impact the appearance, efficiency and guest satisfaction in a hotel. The ability of management to maintain a property is often closely related to the profitability of the hotel (Lockyer, 2013).

3.2 Maintenance worker's productivity in hotel sector

With increasing awareness that maintenance creates added value to the business process; organisations are treating maintenance as an integral part of their business. For many asset-intensive industries, the maintenance costs are significant portion of the operational cost (Ben-Daya *et al.*, 2009). Since maintenance activities are multidisciplinary in nature with a large number of inputs and outputs, the performance of Maintenance productivity needs to be measured and considered holistically with an integrated approach (Ben-Daya *et al.*, 2009).

The productivity of people is typically measured as the ratio of real to estimated resources. In the maintenance perspective, it determines downtime period and resources. The first lowers profits and the second raises costs. In both cases, they influence profitability adversely (Narayan, 2012). Productivity and dependability are crucially reliant on human factors and this is predominantly apparent regarding maintainability and maintenance work (Winterton, 1981). Effective human resource management is one of the most important considerations in creating and maintaining a competitive advantage for a hotel. Indeed, it can improve the productivity of the workers in many ways (O'Fallon and Rutherford, 2011). Furthermore, Training and Development (T&D) is one of the foremost part of human resource management which can influence to improve productivity of maintenance workers.

3.3 Importance of Training and Development for the maintenance workers

Organisational training is usually viewed as a public advantage to the point that employees discover it challenging to even regard as transferring any new acquired skills in training to their working surroundings (Hassi and Storti, 2009). T&D today is increasing recognition as a way of expanding skills, enhancing productivity and class of work, and building employee loyalty to the firm. Most importantly, it is a tool for increasing entity and organisational performance to achieve business results (Hooi, 2009). Training aims to develop current work skills and actions, whereas development aims to increase abilities in relative to some future position or job, usually a managerial one (Dowling *et al.*, 1999). When the organisation invests in improving the knowledge and skills of its employees, the investment is returned in the form of more productive and effective employees (York, 2009). Managing workforce of hospitality related company is somewhat different from other businesses. Hospitality businesses supply series of services and so employees should take in to account individual favourite of each customer. Therefore effective training is the basic element of success in the hotel industry (Amirtharaj *et al.*, 2011).

Organisations also get benefits through T&D programmes along with the employees in many ways. Figure 1 shows the employee benefits and organisational benefits of T&D programmes.

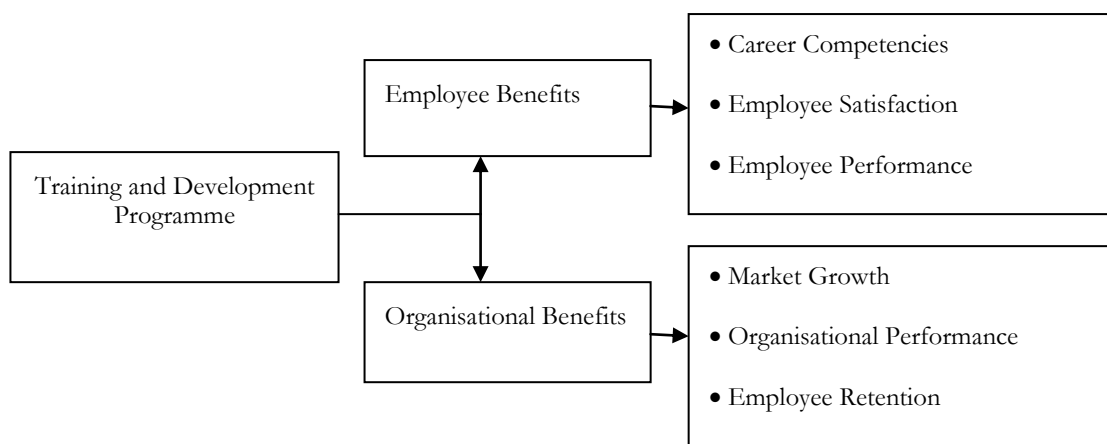


Figure 1: Employee and organisational benefits of T&D

Source: Jehanzeb and Bashir, 2013

4. Research method

Case study was adopted as the most suitable research method for this study as it provides an in depth understanding about the subject being studied not usually offered by other qualitative methodologies (Hancock, 1998). Furthermore, Yin (2009) stated that, the use of the case study methodology is appropriate when organisational and managerial issues need to be examined. As such, semi-structured interviews were considered as ideal because it draws more elaborative and persistent answers from the respondents to the raised questions. Being so, the interviews were carried out among Human Resources Managers in the hotel industry and content analysis was conducted to analyse the interviews. Further, to achieve the data triangulation a questionnaire survey was conducted to rate each important and satisfaction aspects of the maintenance workers about training and development.

Three Sri Lankan hotels were taken as cases for this study. All of them are three star hotels with less than 30 maintenance staff. Descriptions of the cases are presented in the Table 1.

Table 1: Profile of the cases

Cases	Hotel A	Hotel B	Hotel C
Type	3 Star Hotel	3 Star Hotel	3 Star Hotel
Description	Land area 36 acres, 105 guest rooms, bar, restaurant (à la carte), restaurant (buffet), Garden, terrace, outdoor pool	Land area 32 acres, 125 guest rooms, bar, restaurant, gym, shopping arcade, seafood restaurant, swimming pool, night club	Land area 27 acres, 116 sumptuous rooms, a Presidential suite and 6 suites, medical facilities, restaurant, bar, exhibition hall, conference rooms, banqueting
Type of customers/ occupants	Business guests and guest for functions such as weddings, meetings etc.	Business guests and guest for various functions like conferences	Tenant employees and their clients
Maintenance Staff	26 workers with one maintenance engineer and two maintenance supervisors	23 workers with one maintenance engineer, one assistant engineer and three supervisors	27 workers with two maintenance engineers and four supervisors

5. Research findings and discussion

Collected data were analysed under four different themes as shown in Figure 2.

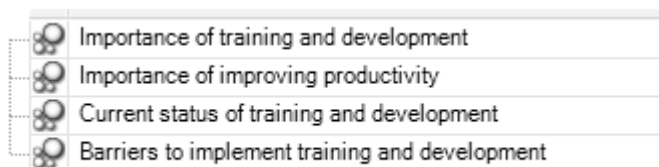


Figure 2: Coding structure of research themes

5.1. Importance of T&D in hotel sector

Nature of T&D programmes differ from industry to industry. However, all the industries need to train and develop their employees to stay ahead of the competition of their own industry. According to the findings, all the interviewees understood the importance of T&D. Human Resource Manager (HRM) of 'Hotel A' emphasised that, *'Training programs helps to improve the productivity and efficiency of an employee. Since it saves time we can assign the employee for another task in his idling time'*. This statement proves that T&D programmes are value additions and have a positive relationship with the organisational success. Further, HRM of 'Hotel B' stated that, *'Training and development can motivate the employees towards their work'*. Choo and Bowley (2007) also proved the same statement from their study.

Even though the top management agreed that T&D is important for the development of the staff, the questionnaire survey which was carried out among hotel maintenance workers proved that the workers are not 100% aware about the importance of the T&D programmes. Figure 3 illustrates the results of the questionnaire survey on importance of T&D programmes for maintenance workers.

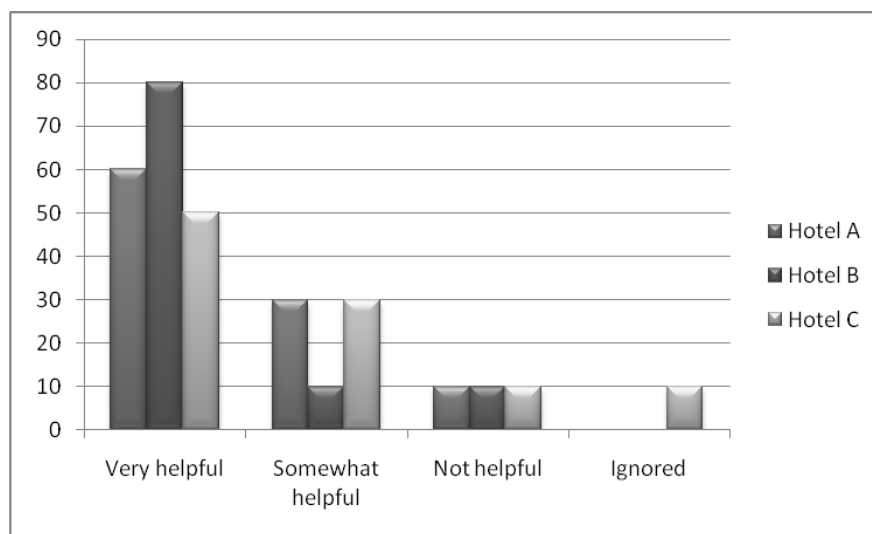


Figure 3: Importance of T&D
Note: Rated by maintenance workers

Based on the figure, majority of the workers agreed that T&D programmes are interesting and helpful. However, around 20% of the workers are not understood the importance of the T&D programmes. The top managements have to take necessary actions to improve employees' knowledge and awareness to enhance their commitment towards T&D programmes. Otherwise, the organisational and personal benefits will not be achieved through T&D programmes by both employers and employees.

5.2. Importance of improving productivity

Productivity can be defined as the percentage of the total time a worker spends on productive work (Groote, 1995). As described beforehand, T&D programmes will improve the productivity of the workers. However, importance of improving workers productivity for an organisation should be understood by the management. According to the interview results, all the HRMs are aware about the importance of improving the productivity of the employees. HRM of the 'Hotel A' stated that, *'Training and development can make a person more knowledgeable. So, the workers can develop their career and ultimately it will improve their living standard'*. Further HRM of 'Hotel C' stated that, *'Workers' productivity improvement will beneficial to the organisation as well. It will reduce the burden of the top level managers and will increase the profitability of the organisation as well'*. The opinions of both HRMs proved that, improving productivity of the workers is a value addition to the employees as well as the organisation.

5.3 Current status of training and development in the hotel industry

Findings of the study revealed that, T&D programmes for maintenance workers are not conducted regularly or sufficiently in all the selected cases. According to HRM of 'Hotel A' *"we don't conduct any regular training and development programmes for the maintenance workers due to budgetary constrain. However, we invite industry experts occasionally to share their knowledge and experience with our workers."* Furthermore, HRM of 'Hotel A' confessed that, *"the trends of T&D are improving year by year. Yet, I am not aware about new trends of T&D programmes"*. The statement confirms the unawareness of the management's lesser commitment towards workers' improvement.

Similar status has been observed in the other two cases as well. HRM of 'Hotel B' stated that, "Even though we don't conduct any regular training and development programmes, we conduct fire and safety seminars to our maintenance workers according to the requirement". However, fire safety seminars for the occupants are mandatory to ensure the fire safety of the building. It will not improve the productivity related to the maintenance job of the workers. Further, according to HRM of 'Hotel C', the hotel is in the process of regulating and scheduling of T&D programmes.

Maintenance workers were required to rate the current T&D programme of the selected cases in order to find their opinion towards the current practices. Approximately 75% of the workers found T&D programmes very helpful in the previous survey. However, majority of the maintenance workers are not satisfied with the current status of the T&D programmes in all the selected cases. Figure 4 shows the results of the survey.

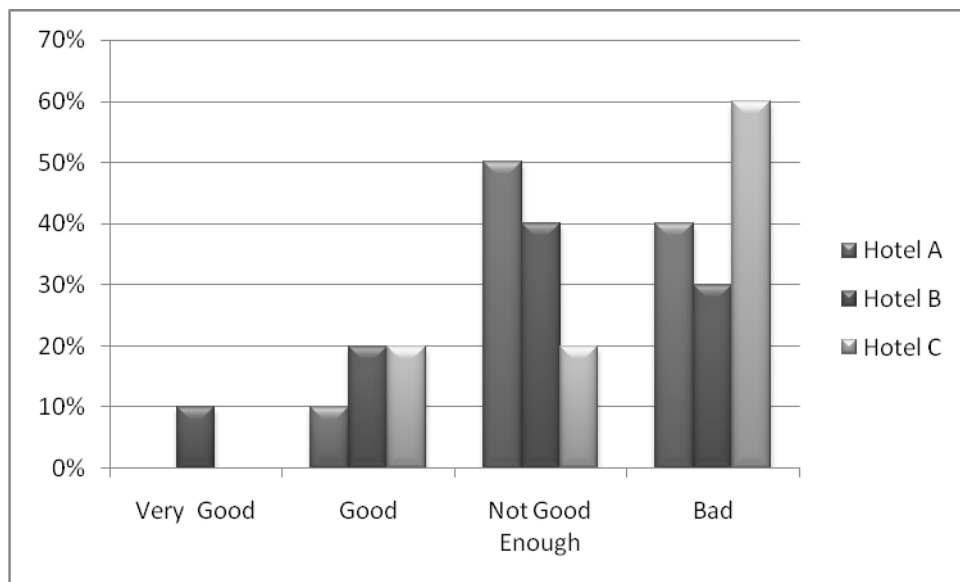


Figure 4: Current status of T&D programmes

Note: Rated by maintenance workers

5.4 Barriers to implement training and development programmes in hotel sector

Findings revealed that, none of the selected cases are conducting regular T&D programmes for maintenance staffs. Figure 5 illustrates the reasons stated by the management. According to the figure ignorance of both management and the workers is the main reason for not conducting regular T&D programmes. Moreover, organisation's unawareness, budgetary constrains and unavailability of experts to conduct training programmes are admitted as other reasons.



Figure 5: Reasons for not conducting regular T&D programmes

In the workers' point of view one of the reasons for their lack of commitment towards T&D is difficulty in understanding. Figure 6 shows the rating of the employees.

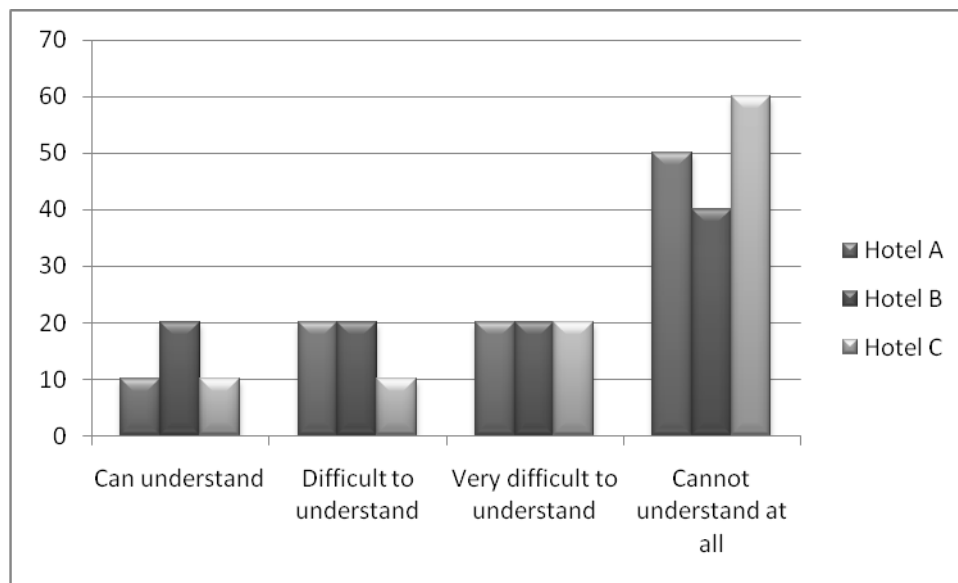


Figure 6: Level of difficulty in understanding T&D programmes

Note: Rated by maintenance workers

In accordance with the figure, around 50% of the workers are unable to understand the lectures/ discussion of the T&D programmes. One of the main reasons for this result is, most the T&D programmes are conducted in English language. Around 65% of the maintenance workers who are not well-informed in English cannot understand the content of the T&D programmes. As a consequence, organisations' resources and the time of the workers will be spoilt. Thus, organisations have to plan on the efficiency of the programme before conducting it. Before conducting T&D programmes, identifying the correct target group is the foremost job. Target groups can be divided based on experience of maintenance workers, age of the maintenance workers, educational level, availability and the category of the maintenance workers.

5.5 Training and development framework

Literature and findings revealed that, T&D will improve the productivity of the workers. However, in the Sri Lankan hotel sector T&D programmes are not conducted regularly. Many reasons expressed by the management and workers for the malpractice of T&D. As a key recommendation, a T&D framework is developed to provide a guideline for the practitioners based on the suggestions given by the respondents of the cases. Figure 7 illustrates the T&D framework.

Figure 7 includes the steps to be followed by the management during the organisation of T&D programmes and their outputs. First step is identifying the target group. During this step age, experience and educational qualifications of the workers should be taken into consideration. Second step is identifying the requirement. Requirement of the hotel management and requirement of the workers can differ according to their positions. Further, current status of the T&D of the hotel is also taken into consideration in this step. Next step is the selection of experts. During this step availability of the experts should be analysed and organisation's budget allocation to the T&D programmes should be compared with the availability of the experts. Finally T&D programme should be conducted and the feedback of the programmes should be taken from the workers for future improvement. By following these steps, all the benefits of the T&D can be achieved.

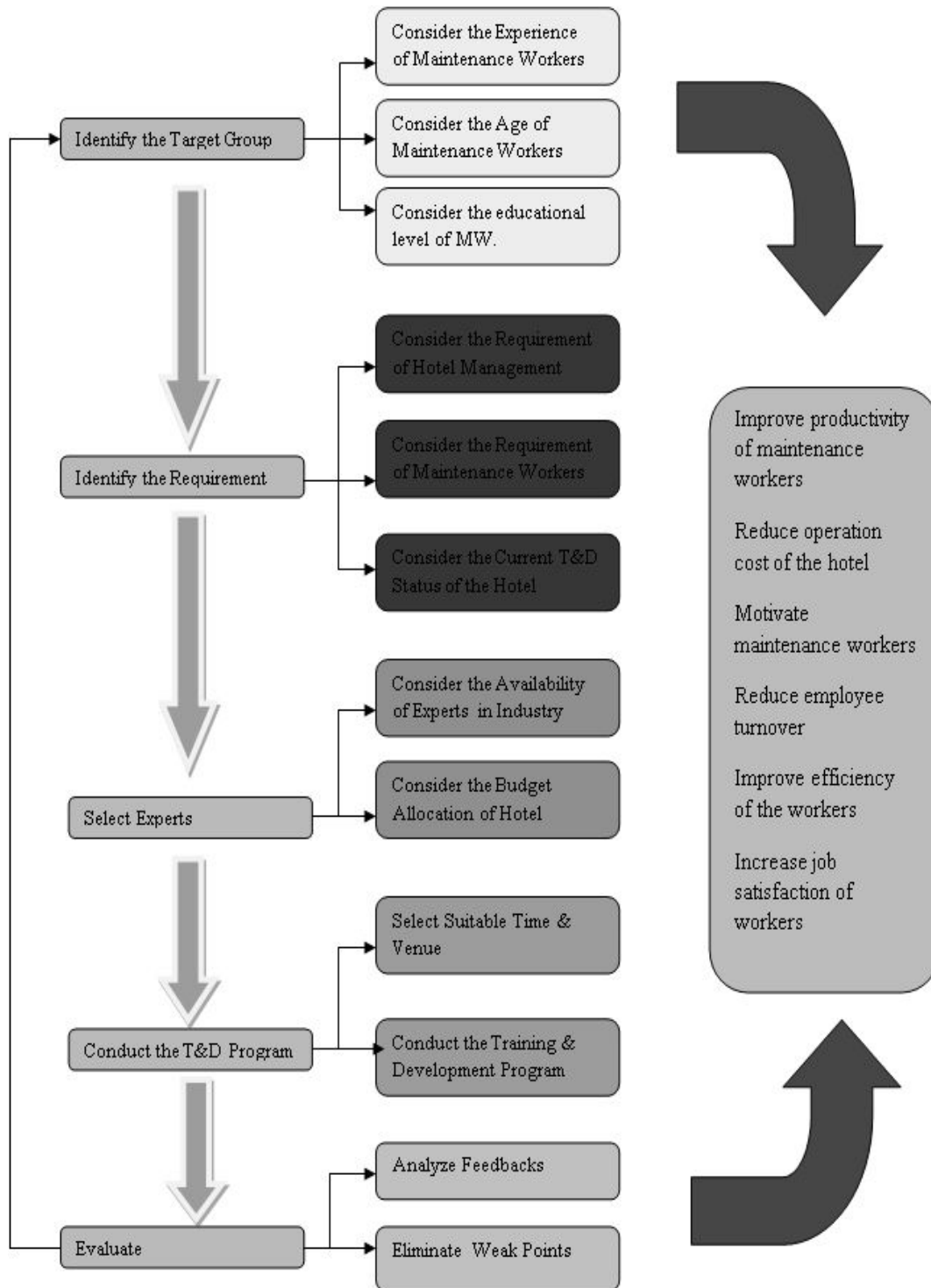


Figure 7: Training and development framework

6. Conclusions

Training and development can play a significant role within the organisation to improve productivity of the workers. According to the findings HRMs are reluctant towards conducting T&Ds. This is due to many reasons such as, budget constraints, unawareness, commitment of the workers, and constraints on getting the resource persons. Moreover, maintenance workers also not committed due to their educational level, language barriers and busy working schedules. In order to avoid the disadvantages that may result from malpractice of T&D, organisations need to adopt a systematic approach. Steps for organising T&D were identified from the literature and related with the findings to provide a T&D framework for the practitioners.

This study was limited to the hotels in a particular city of Sri Lanka. Case study samples were limited due to the scale of the study and the time constraints. Therefore this study can be continued to different work fields with a bigger set of sample.

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Construction and Demolition Waste Management Gaps in Construction Industry

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Abstract

Construction and Demolition (C&D) waste is one of the fastest growing waste stream in Sri Lanka due to the construction boom after three decade of war. Thus, C&D waste management has become an environmental problem due to the lack of treatment and uncontrolled land filling. Thus, this study is focused on identifying the gaps which need to be addressed in C&D waste management.

Survey approach and interviews were used to gather information. Consequently, ten semi-structured interviews were conducted with experts involved in C&D waste management. The collected data was analysed using content analysis technique.

The findings revealed that the major gaps exist in C&D waste management as lack of capacity to handle an enormous quantity of waste, difficulty in estimating the quantity and composition of waste, lack of dumping sites and coordination among different parties involved, financial incapability and lack of technical people. Therefore, the study proposed seven areas for improvements as institutional and legal framework, fund allocation, site waste management plan, waste management hierarchy, supportive environment and monitoring, evaluation and reporting.

Keywords: C&D waste, Waste management, Gaps, Construction

1.0 Introduction

Construction and demolition waste is generally defined as waste which arises from construction, demolition and renovation activities including land excavation, site clearance, civil and building construction, demolition activities, roadwork, and building renovation (Yuan, Shen, & Wang, 2010). However, lack of awareness of resource-efficient construction practices has resulted in excessive use of natural resources and generation of large amounts of C&D waste that is rarely recycled (Borongon, & Nitivattananon, 2007). C&D waste has become one of the major concern in lot of developed and several developing cities throughout the world. Waste has even been seen as a crisis in these cities because landfill space is exhausted at a rate much faster (Mou, 2008). Central governments, regional and local authorities in many developed countries have policies related to the management of C&D waste (Borongon, & Nitivattananon, 2007). These all include a commitment to minimize generation of C&D waste and to adopt waste minimization strategies that because of the shortage of landfill facility (Addis, 2006). The foremost benefits through applying this approach are considered as the prevention of creating new and undesirable landfill sites, stemming potential environmental health risks related with C&D waste and its disposal and reducing the cost of construction (Lingard, Graham, & Smithers, as cited in Tam, Shen, Fung, & Wang, 2007).

Sri Lanka is a developing country and the construction industry contributes average 7.1% to the GDP (Central Bank of Sri Lanka, 2012). This contribution factor expected to be higher in future years due to government concentration on expedite development activities in all areas after the war. C&D waste form construction projects are inevitable but waste cannot be illegally disposed. Due to rapid development in construction industry, C&D waste has become one of the major concerns in future. Relevant authorities have little focus on C&D waste management at present. However there should be a proper management system to implement in the future to the expedite development programs forecast in the country (Kumara, 2009).

To have a better C&D waste management system it is important to recognize the existing gaps. Consequently feasible solutions to overcome the identified gaps should be identified. Thus, this research is focused on identifying “the gaps in existing C&D waste management and probable solutions?”. Accordingly the paper covers what is C&D waste management, adopted methodology and the research findings.

2.0 Construction and demolition waste management

C&D waste stems from construction, refurbishment, and repair work, and can emerge at any stage of a project from inception to completion. Generation of the waste stream is affected by various causes. According to Gavilan & Bernold (2008) these causes can be classified into six categories namely design, procurement, handling of materials, operation, residual related and other.

Compared with municipal waste, sources of C&D waste can be readily identified and the composition of C&D waste is relatively well-defined. In accordance with the composition of C&D waste it can be classified into two major parts such as inert and non-inert waste material. The inert material can be categorized into two major parts namely soft and hard inert material. The soft inert materials contain soil, earth, silt, slurry as well as hard inert materials contain rocks and broken concrete and non-inert materials include timber, plastics, metals and packaging waste.

In past, C&D waste was simply dumped in open dumps or the sea as the final treatment. Some of them were used in earth filling works however without much effort on waste separation. The aim of C&D waste management is based on minimization of waste and proper disposal, which both two help to reduce adverse environmental impacts and positively affect to the social economic and economic performance (Ye, Yuan, Shen & Wang, 2012). The European Union (EU) suggested a strategy for waste management based on waste hierarchy which gives preference to the prevention of waste minimization, then the recovery of waste and ultimately waste disposal (National construction & demolition waste council in Ireland, 2008). Moreover, C&D waste can be managed through “3Rs” principle (Lu, & Yuan, 2011). The 3Rs are refer to reduce, reuse, and recycle, which classify waste management strategies according to their desirability (Peng, Scorpio, & Kibert, 1997).

3.0 Research methodology

The survey method is adopted to find out the existing gaps and probable solutions for C&D waste management in Sri Lanka. Semi-structured interviews were selected to gather relevant information from experts who involve in solid waste management because semi-structured rather than structured interview enable sufficient flexibility to approach different respondents differently while still covering the same areas of data collection (Noor, 2008). The sample size of the study was limited to ten because of the limited number of experts involving in C&D waste management in Sri Lanka. Interview guidelines were prepared prior to the data collection. The design of the interview guidelines was done in accordance to capture the required data to analyse the research problem. The questions of the interview guidelines were developed based on the objectives of the study. While interviewing, note taking and tape recording were done to maintain the accuracy of data collection and avoid losing data as it is impossible to note down everything during the interview. The collected data were analysed using the content analysis technique. During write-ups, key findings were cross-referred with the related literature findings.

4.0 Findings

This section elaborates the gaps in existing construction and waste management practices and policies and probable suggestions.

4.1 The Gaps in existing C&D Management in Sri Lanka

4.1.1 Low percentage of on-site waste sorting

In the current scenario the C&D waste generated in construction sites are mixed. Local authorities and contractors not much consider on site waste sorting. According to the gathered data, all type of C&D waste collect without separation. This will lead to reduce efficiency of recycling and reusing of C&D waste along with a reason to increase reuse costs for construction companies. Moreover the waste collection parties do not consider on the toxicity of the waste and finally put them all into landfill without any separation. This will lead to increase environmental pollution, soil pollution and create bad impacts for the health and safety of people.

4.1.2 Lack of awareness on construction waste reduction

Waste reduction is the best waste management practices among the 3R waste management policies. Through interviews, it is identified few reasons for poor waste reduction in construction project. C&D waste management is new area in Sri Lankan construction industry therefore most of architects and designer are not aware the importance of waste reduction during planning and design stage. Lack of awareness of waste minimization design and construction alternative methods and design changes occurred in construction stage is the major factor for waste generation due to architectures unawareness of the importance of waste management. During the construction stage bulk amount of waste can be generated due to poor site waste management plan.

4.1.3 Lack C&D waste recycling facilities and systematic planning

There are no enough C&D waste recycling facilities in Sri Lankan construction industry. There is an only one plant established in the country named COWAM. COWAM plant is operating in the 14 days per month due to limited number of employees and limited quantity of C&D waste availability. Due to high cost of waste transportation contractors are not willing to transport the generated waste to the plant. Due to the same reason Galle local authority which owns the plant is not willing to go sites and collect the waste.

4.1.4 Lacking of a market for recycled products

Lack of awareness of recycling market for the C&D waste is a significant factor preventing the expansion of recycling in Sri Lanka. Moreover market values of C&D recycled products are low with less customer satisfaction on the quality of the recycled products and companies are afraid to go for new products. In the current situation most of the recycled materials are used for road works.

4.1.5 Limited landfills for receiving C&D waste

In Sri Lanka, presently amount of C&D waste generation increasing rapidly with the rapid development of construction industry. Local authorities are responsible for the waste collection and disposal. There are only few permanent landfills are belong to the local authorities and this amount is not sufficient to the dispose all the waste generated in construction sites. According to the literature foreign countries have common C&D waste disposal sites to operate proper disposal system for C&D waste. However due to lack of landfills in Sri Lanka, people used to dump C&D waste everywhere creating environmental and social problems. Therefore, the inadequate facility of landfills in Sri Lanka is a main barrier to C&D waste management.

4.1.6 Low charge for collection C&D waste

Currently Sri Lankan local authorities charge maximum of Rs. 2000 per tractor and Rs.1500 per half of tractor in C&D waste collection. However waste collection charges of developed countries are higher than the Sri Lankan charges. When the charge is low, there is no influence on the waste reduction, reuse or recycling. However according to the local authorities, C&D waste is not a big issue for the environment and therefore they are not geared up to increase the fee of C&D waste collection.

4.1.7 Unavailability of a centralized body

In Sri Lanka there are responsible bodies for managing municipal solid waste and hazardous waste however there is no responsible body to manage C&D waste. Furthermore it was revealed that establishing a separate body for managing C&D waste is high costly with allocating a place, allocating funds and allocating human resources for a separate body. Similarly, managing C&D waste has not been felt as a need for the government.

4.1.8 Unavailability of a national policy

Findings revealed that complexity of making a national policy due to time and cost constraints have caused for the unavailability of a national policy. Furthermore negligence of government and relevant ministry on C&D waste issues has exaggerated the problem.

4.1.9 Less rules and regulations on C&D waste management

The existing laws and regulations for waste management in Sri Lanka are imperfect to manage C&D waste. It is not helpful to increase the rate of recycle, reuse of waste and decrease the illegal disposal of waste. Moreover, C&D waste cannot manage through the existing general waste management rules and regulation. Therefore special rules and regulations are needed to better C&D waste management practice.

4.1.10 Limited researchers conducted regarding C&D waste management

Lack of awareness on importance of C&D waste management and lack of funds allocation for C&D waste management have created limited researchers for waste management. Due to these reasons limited researches are conducted regarding C&D waste management. It is generally identified researches are necessary for improvement of C&D waste management field.

4.1.11 Lack of commitment of government and local authorities

C&D waste management should be initiated by the central government and local authorities. Generally, laws and regulations are imposed by the government and by laws are imposed by the local authorities. Additionally waste management is a responsibility of local authorities. Furthermore most of the massive construction projects are done by the central government. Therefore government can deliver greater support to manage C&D waste. However government and local authorities confer lack of commitment for the C&D waste management in the current scenario.

4.1.12 Lack of community awareness on C&D waste management

Ordinary people are not much aware on the new demolition techniques and benefits of reusing C&D waste. Therefore they demolish houses without considering reuse of material. Majority of the interviewees expressed people are not aware of the recycling market of C&D waste. Due to lack of awareness on C&D waste management people used to put waste everywhere. Additionally, people are not aware on the effects of hazardous waste and collect toxic and non toxic waste together and put to the landfills.

4.1.13 Lack of skills of labours

Skill levels of construction labours are directly affects the generation of construction waste. Most of the appointed labours are not permanent and most of the time they are farmers before joining to the project without training or experience on construction methods, materials, handling of construction material. Due to insufficient skills of labours, generate more wasted plastering and form work.

4.2 Probable Attributes and Suggestions

The previous section identified several gaps in existing C&D waste management practice. This section attends to determine probable suggestions to mitigate gaps in C&D waste management.

4.2.1 Providing on-site sorting facilities

Providing on site sorting facilities will increase the efficiency of C&D waste management. Through the corporation of government and local authority can be provided on site sorting facilities and required awareness programmes to recover usable material. Providing on site sorting facilities will increase the proportion of construction waste reuse and recycling and decrease the environmental impact.

4.2.2 Creation of markets for C&D waste recycled products

Involvement of government is the optimal solution to create market for recycle product. In Sri Lankan context government is the biggest client in the construction industry. Recycled products can be used in government construction projects. Through the involvement of government in recycling industry there is a guarantee for quality of recycled material. Moreover this will convince private sector to use the similar recycled products with an assurance. When government trust the quality of recycled products, market for the recycled material are stable as there is a strong client to buy recycle products. Government can provide guidelines to the recycling companies, give opportunities to take new technologies and knowledge from developed countries and provide facilities to improve the industry.

4.2.3 Innovations and creativity in sorting, reducing, reuse and recycling of C&D waste materials

Researches and technical innovations are needed to identify new ways for C&D waste reduction, reuse, recycling and sorting. The low-waste generation designs and low-waste construction technologies minimize the generation of construction waste. Use of new construction methods and new construction materials will optimize the uses of unnecessary construction materials. It needs to identify the current trend of construction industry and market then developed a solution to optimize the reuse of C&D waste.

4.2.4 Awareness programmes on C&D waste management

Awareness on C&D waste management directly affects the efficiency of waste management. Thus it is important to have awareness programmes to the contractors, technical staff and school and university students about importance of waste management. These programmes should address the community on environmental, social and economic benefit of C&D waste management. This will improve C&D waste management practices. Government can play a major role in this with the help of non government organization as they can be incorporated with experienced persons on C&D waste management.

4.2.5 Communication system among stake holders

In Sri Lankan context there is no communication system to share information on C&D among the stake holders. In this situation the government can develop a database on C&D waste management system including new demolition techniques, reuse and recycle practices and details of stakeholders involving in C&D waste management process. The communication systems will link clients, contractors and waste collection organizations. Therefore a communication system is essential among parties involved in C&D waste management.

4.2.6 Evaluating and monitoring of C&D waste management procedure

The experts' opinions gathered through the expert interviews identified a standardized evaluation and monitoring system as essential for C&D waste management. At the moment responsible authorities are not concerned with C&D waste management. Government should monitor the waste management practices of construction sites. Moreover contractors should evaluate their waste management procedures to bring in a cost saving by reusing and recycling of material.

4.2.7 Develop statistical information system for amount of C&D waste generation

Statistical information on waste generation is essential for proper waste management practice. However most of the local authorities or municipal authorities have not regulated statistical information on amounts of construction waste generation. Through the proper coordination of local authorities, government and contractors can develop a statistical information system to calculate the amount of construction waste generation per month. With the understanding of amount of waste generation can provide recycling facilities for the areas which generate more C&D waste.

4.2.8 Vocational training for labours

It was revealed that lack of skills of construction workers has a greater impact on C&D waste generation. Most of the experts expressed that giving opportunities for labours for vocational training can reduce the construction waste generation. Vocational training programme can be conducted by training organizations accredited by the government. The training programmes should be continued and should contain the information of construction materials and new construction techniques.

4.2.9 Setting up administrative bodies for C&D waste management

In the current scenario Central Environmental Authority, Waste Management Authority and National Solid Waste Management Support Center have the authority to administer solid waste management in Sri Lanka. However these authorities are involving in C&D waste management in an indirect way and it cannot expect an effective C&D waste management system through the current system. In contrast to the Sri Lankan level developed countries have established separate bodies for C&D waste management and through these organizations they have executed legislations, policies and administered waste management practices of contractors and waste collection companies. Hence, it is clear that allocating responsibilities for C&D waste management to a separate institution can support to create a better C&D waste management system.

4.2.10 Development of new rules and regulation for C&D waste management

Findings revealed that there are some provisions in the National Environment Act and its amendment to assure environmental responsibility and social responsibility of C&D waste. However C&D waste management related rules and regulations are incomplete and new rules and regulation should impose to separate hazardous and non hazardous waste generated in C&D projects.

4.3 Implications of the study

4.3.1. Fundamental areas to be considered in C&D waste management

The theoretical framework of the research study was developed by expressing suggestions and recommendation for a C&D waste management system. The framework summarized seven fundamentals as an institutional and legal framework, fund allocation, site waste management plan, waste management hierarchy, supportive environment, awareness of waste management of client, design team, contractor and sub contractors, and monitoring, evaluation and reporting waste management (Refer Figure 1).

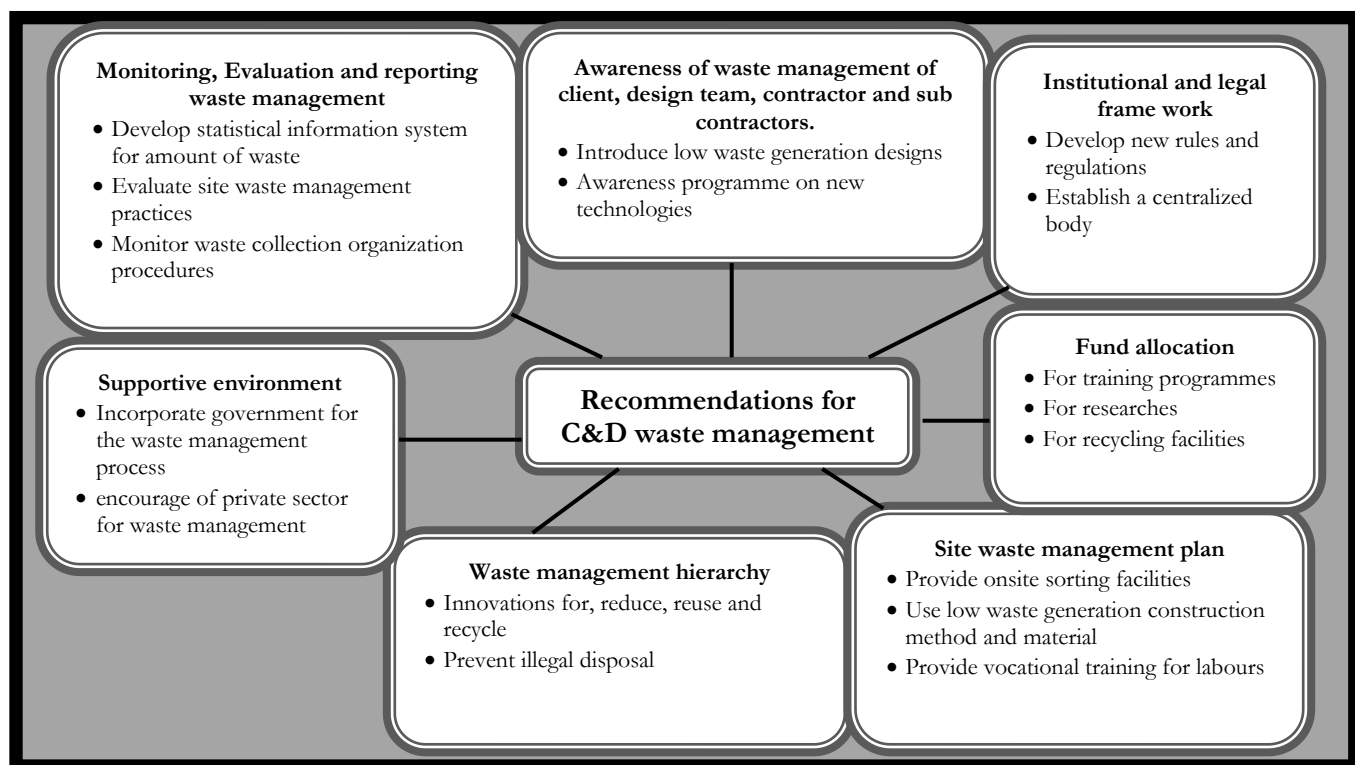


Figure 1: Developed theoretical framework of the study

4.3.2 Role of Government in C&D Waste Management

Findings revealed that the central government has a major role in C&D waste management. In dealing with C&D waste the government should act more reactively than other stakeholders. The government should take steps to promote waste management practices in the construction industry and should encourage the construction industry to implement these practices.

- Government can play different roles in the management of construction waste namely contractor, regulator of C&D waste management, user of the reused and recycled material and as a market creator for waste materials.
- Sri Lankan government lacks strong political views for the implementation of waste management practices and policies. The Government should develop national policy for C&D waste management to improve actions of

waste management. Through this process government could also establish the requirements of specifications and technical guidelines on C&D waste management practice for contractors.

- Laws and regulations for C&D waste management are less visible in Sri Lanka. Thus, implementation of strong rules and regulation for C&D waste management is important. The government shall impose rules to the contractors for reuse and recycling of waste generated in construction project instead of disposing to illegal land filling with the involvement of expertise. After the real application in construction industry the government can identify the limitations and then these can be addressed by the further amendments.
- Government can play a special and meaningful role in the initiation and development of waste management and recycling market in Sri Lanka. Firstly government has to take risks to invest for recycling facilities and technologies as at present recycling market has a big risk. The government's involvement will build up the confidence among the other stakeholders. Additionally, government can establish recycling plants through the local authorities. It will create more recycling plants than the landfill sites. Therefore the contractor's motivation to recycle the C&D waste will high due to economical benefits which can gain through recycling rather than land filling.

Therefore it is crystal clear that the government has a key responsibility in filling the gaps in existing C&D waste management system in Sri Lanka. Moreover it was identified that thorough government intervention is much important to deal with issues of C&D waste.

5.0 Conclusions

6.0

The ever increasing C&D waste generation makes urgent need to realize importance of managing C&D waste and implementation of comprehensive national strategy and a policy specially deals with C&D waste management. C&D waste is a solemn threat which was faced by the whole world thus there is a major attention to manage C&D waste. In this study, several concepts, practices and strategies in C&D waste management were identified which are significant in global and Sri Lankan context.

The existing gaps in C&D waste sorting, collection, disposal, reuse and recycle practices can be alleviated through the identified suggestions (Figure 1). Moreover government can develop new rules and regulation, set up administrative bodies, develop communication linkage among stake holders, develop statistical information system for generation of waste, create market for recycle product, develop recycling facilities and evaluate and monitor waste management procedures to address the gaps in existing C&D waste management practices. Ultimately this will create an environmentally, economically and socially feasible C&D waste management system.

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An Investigation of Key Factors to Uplift Traditional Lac (*Laksha*) Craft in Sri Lanka

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Abstract

Lac craft is a traditional craft in Sri Lanka and it has a traditional immense and endurance history. Lac is one of the decorative medium that can be applied on different types of materials, such as wood, ivory, pottery, clothes, horns, shells etc. Lac craft is an identical precious craft in Sri Lanka. But in current society it is not uplifted to cater present social needs. This can be considered as a dying industry and as a traditional craft that was continued from generation to generation, even though it is not continued as before. As the knowledge is not transferring to future generations; it will become a dilapidated craft in the craft milieu after three or four generations. It is needed to accompany for future generations to identify their tradition ethics, tools, equipment, decorations, manufacturing methods and market opportunities.

This research oblige to identify the key factors that can affect endangered and upgrade to cater the present social needs which is a current need of the craft industry in Sri Lanka. It is a cast based industry and it was continued in several rural areas in Sri Lanka with a traditional identity, by the way still it continues in few areas in country. Especially craftsmen of Kandy and Matale districts still continue their practices in traditional manner. This research generally considers the craft places in central province to gather factual data.

The methodology of the research was based on the Grounded theory method. The research followed the quantitative and qualitative research methods. The required data were collected through an extensive literature survey, case study use of variety of Lac crafts and structured questionnaires given to the people who are engaging in Lac work in Pallehapuwida to identify main factors that are affecting to uplift the Lac craft. The research identifies main six key factors in order of the importance as introducing new technology, new designs, new materials, introducing new colour by experiments, conducting trainee programmes, and teaching as a traditional technical subject. These are the main key factors that should be considered to uplift the dying tradition of Sri Lankan lac craft to get keen and endorsed future.

Keywords: *Uplifted, Traditional, Design*

1.0 Introduction

Sri Lanka had a great endurance history for traditional art and craft industry. It was famous through the world for its exquisite handicrafts and elegant handicrafts sectors were established all around the country. Lac work or *Laksha* is one of the superlative craft category that could be identified in the craft milieu.

Lac craft is a cast based industry. It was continuing from generation to generation, even though it is not continuing as before. The origination of this craft goes back to back feudalism era. People who engaged in the Lac craft had to serve the king ship serving with different types of objects out of Lac work. The material usages of Lac work were hundred percent natural and consisted with eco-friendly substances. It can be identified as one of the decorative fusion that can be applied on different types of materials such as, wood, ivory, pottery, clothes, horns, shells. It had a great and endurance history, but in current society it is not uplifted to cater present social needs and social demands. It will become a dilapidated craft in the craft industry, after few generations. The industry has been identified as one of the elegant handicraft in Sri Lanka. It was observed that Sri Lankans have resorted to introduce new materials, techniques, Designs and new avenue to preserve this craft.

Thus the main objective of this research is to identify main key factors to uplift Lac craft industry in Sri Lanka. The paper begins with literature review, research limitations, research method, historical background of lac craft, manufacturing processes, results and discussion, conclusion and recommendations. Finally, it tries to identify the key factors to uplift the traditional Lac work.

2.0 Literature Review

The craft is based on the Natural Lac, which is a main material of the *Laksba*. It can be recognized in different names like Lac, *Laksba*, *Lakiri* and also identified as a surface decoration method for the materials as mentions (see section-0.1). It helps to add additional value to the products. Lac craft is not originated in Sri Lanka. It was transferred from other countries with their cultural influences. Lac craft had a golden era in the feudalism period. According to the legend they had to serve to the kingship providing with different products.



Figure 2.1: Lac work object – Colombo National Museum

Origin of the Lac craft goes back to pre-historic era. As a legend it transfers from the people who came with queen *Baddhakachchayana* or *Theri Sangamiththa*. It is quite doubt full how it was established in Sri Lanka, any way it proved that it was transferred from India. And in the other hand one of the legends has discovered that Lac work have had a grate era; because a king of *Divya Kasasthawansha*. He made eight *karadus* out of lac work. Mostly lac workers are identified as *I-vaduo*; people who make arrow; the legend discovered that *beeya*, and hella is made in the period of Ramarawana. According to these facts, Lac industry has had a great history. People who are engaged in the lac craft had a talent to make quality products to challenge Indian products. “ such ornament in kandyan districts is almost invariably confined to incised lines and circles similar to work from Jonhpur in India” Coomnaraswamy (1979). It is proved that Sri Lanka had a great history for the Lac craft specially in the mediaeval period.

3.0 Research Limitation

In past Lac craft was spread out all around in the Sri Lanka, but in present it is continuing in several rural areas and has become a delapidated craft. In Kandy district still it continues as a traditional manner with cultural identity. This research is mainly focusing on the craft places in central province. Pallehapuvida in Matale district is famous for Lac craft from the ancient time. Still they continue their craft in traditional manner. It was famous for *Niyapothuweda* rather than the *Pattabweda*. Because of that, this research focuses on the village of Pallehapuvida to gather factual data.

4.0 Research Method

The research method was based on the Grounded theory method and the required data were collected through an extensive literature review, actual description of observer, experience of the craftsman, case study use of different types of Lac work use in current society. Quantitative and qualitative research methods are adopted to collect data. To collect factual data structured questionnaires were given to the people who are engaging in Lac work in Pallehapuvida to identify main key factors that are affecting to drawback the Lac craft. The questioner consisted with 20 questions which are followed open needed and close ended questions. It was distributed among 50 people who are engaging in Lac craft in the Pallehapuvida.

5.0 Historical Background of Lac Craft and Craft Evolution

Lac work in Sri Lanka is a famous handicraft in Kandyan era. During the Kandyan kingdom from the 15th to 18th centuries, art and craft became extremely organized and received royal patronage. Lac workers or *I- Vaduo*, literally “arrow makers” are the lower division of the *archario* or *Namandanno*. As mentioned above they had to serve the king ship. There are two types of manufacturing methods in the process of Lac work. Generally they did both the wood turning and ornamentation. They had to provide bows, arrows, spears, staves, and bed legs, handle of cressets, banner poles, powder horns, oboes and book covers out of Lac.

At the beginning this craft was established in several areas; but in present it can be considered as a dying industry and as a craft that was continued from generation to generation, but it is not continuing as before. This craft still continues in several places, specially Central province in Matale district Pallehapuvida, Hurikaduwa, Balangoda- Pallekanda, and down south Angalmaduwa near Tangalle.

Lac is a nontoxic natural resin secreted from the bark of certain trees that have been infested with the Lac beetle. Ceylon Lac is the product of two species of the Lac insects.

1. *Keppetiyā* or *Kon-Lakada* – It is collected from the trees of *Keppetiyā*, *Kon*, and *Hinguru* tree
2. *Telakiriya Lakada* - It is collected from the *Telakiriya* tree, the special thing is *Telakiriya Lakada* is brighter and clear quality rather than the *Kon-Lakada*.

These are the trees that can be collected from the *Laksha* in Sri Lanka; sometimes used Indian Lac. Nowadays imported wax called shallack is used instead of Lac obtained from insects and produce.

6.0 Manufacturing Processes of Lac work

6.1 Traditional Manner of making *Laksha*

Lac craft has a quite interesting manufacturing process. Beginning to end of the product it was handled by manually. As special features they have keen and quick talent to produce crafts stage by stage. As mentioned above Lac is a resin secreted from the bark of certain trees that have been infested with the Lac beetle. The resin is scraped from the bark, melted and strained.

“The freshly collected twigs bearing the lac insects are dried in the sun; the resin is then removed, pounded, and winnowed or sifted. The crushed lac is enclosed in narrow bolster shaped bags of thin cloths; the bags are heated over charcoal fires and twisted till the melted lac oozes through the cloth. The lac is scraped off; a part of it is next softened over a fire and attached to the point of a small stick, and then again warmed and a second stick attached” (Coomaraswamy A., p.216). According to the above explanation, a clear idea can be obtained about the process of traditional lac preparation. It is not a simple process but the people who are engaged in the craft served their *rajakariya* as well.



Figure 6.2.1: Original Lac colour

6.2 Colour Preparation

Colours are playing a main character in the Lac craft. Color is one of the silent elements and it can express meaning and add an additional value to the product. Heavy and bright colors were used in the Lac craft industry. Coomaraswamy (1979) explained that, Sinhalese lac work is characteristic by great brilliancy and gaiety of coloring. People did creative decorations sensitively and pleasantly, it was proved by the products that they made. Limited colors were used to decorate Lac work. Red, Yellow, Green, Black are the main colors of the Lac craft. Bright colors were used to fill the surface background and light colours were used to create the decorations. Original lac color is Bright golden brown, the pigments can be applied to the lac by melting the component and pounding the coloured powders. Color pigments are prepared out of natural elements.

Red Colour – Vermillion (Sadilingam)

Yellow Color – Orpiment (Hiriyal)

Green Color – Orpiment +Indigo

Black Co.our – Soot of lamp



Figure 6.2.3: Coloured Lac Strips

Colours were used to apply in background surfaces and also for inlaying in ivory hone and chunk work in past. Common wooden elements, such as *Sesath* poles, Working stick (*Heramity*),



A



B

Figure 6.2.4 (A,B) : Inlaying on Ivory
Colombo National Museum



Figure 6.2.5: Working Sticks

6.3 Colour Applications and Decoration Methods

Lac is allied in two different techniques, *Niyapothu weda* (Nail work) and *Pattal weda* (Pool work /Lathe work). Hurikaduwa in Pathadumbara and Angalmaduwa near Tangalle on the south, are the famous places for *Pattal weda*. The method call *Pattal weda* is practiced with applying in a stick of Lac to the object fixed in to a of a lathe machine. The resulting friction caused by revolving objects melts the Lac making it apply on wooden layer to increase glossy effect. Limited number of objects can be made out of lathe machine. All the items are commercial and the importance is carving and engraving methods can be applied simply. Limited design patterns were applied in the *Pattalweda*, just concentric bands of color known as *adara kondu*. Ornaments, ash trays, walking sticks, wooden handles, latter openers, book ends are examples for products of *Pattalweda*.

Hapuvida in Matale district is famous for *Niyapothuweda* (Finger Nail work) not only that but also they were doing *Pattalweda* in small scale. The work is done mainly with the finger or thumb nail without using any machinery. It is quite interesting process; craftsman has special talent to do it carefully with keen and tiny. First they apply basement layer using with Lac piece and threads used for the decorations on top of the wooden base. The technique involves drawing heated and softened Lac in to a fine threads and laying it in a pattern.

It is proved that; The Lac worker sits with a *chatty* (pot) containing a charcoal fire nearby, for the Lac and objects to be decorated has to be warmed continually. The tools consist of short sticks with a colored lump of Lac at one end; also a strip of the leaf of the tali pot tree, first the object is coated with the ground colour, after which it is warmed over the fire and Lac pressed and smoothed with the talipot leaf. A lump of Lac is warmed and a small piece held between finger and thumb while the rest is pulled away. The Lac is served with the thumb nail and smoothed with the talipot leaf (Serandib, November 2010). Traditional motif were used to decorate the Lac surface like, Floral patterns, *Velvota*, *Kalasdagaya*, *Kolawela*, *Bokola*, *Arimbuwa*, *Pthura*, *Adara kondu* (plain lines), *Binduwa* and *Galbinduwa*, *Kolawela*, *Palapethi*, *Lanugeta*, *Dela*, *Sulivela* are some of them.



Figure 6.3.1: Melting Lac Figure 6.3.1: Niyapothuweda Figure

6.3.2.: Making Laksha Thread

7.0 Identification of the Village Pallehapuvida

Pallehapuvida is the village created for the people of the Lac work during the Kandyan period; it was located in the hills near the Matale, 24km from Kandy. It is the only place where Lac work can be found in traditional manner. The village of Pallehapuvida is renewed for *Niyapothuweda* (Nail works) from the ancient times. The more recently introduced *Pattalweda* or lathe work for Pallehapuvida village. According to the folktale the villagers of Pallehapuvida, they had to gain currency in the period of king Vijayapala of Godapola. And according to another folklore, “was where it all began. Villagers recount how, in the 1630s, King Rajasinghe II sent a messenger throughout the kingdom requesting a craftsman to create window panels with lac-work - probably based on the existing Indian version - for the palace. In a distant village a man named Pusappu hailed the messenger to undertake the job. Indeed the king was so pleased with the work that he gave Pusappu some land, and 30 apprentices, accompanied by an elephant who migrated there. On arrival the elephant lay on its side to relax, so the village was called Hopi hida (“where the elephant lay down”), later Hapuvinda, and finally Pallehapuvida” Hussein (2003). It can be identified that Lac craft was originated in this village.

7.1 Products and manufacturing methods.

In past they used *keppetiya* trees from Nayakumbura to obtain Lac. The name called *Tattu kramaya* was the method of applying *Lakada pati* to the revolving wood, One after the other to form layers of different colors. First, they applied Yellow colour, then Red and finally applied Black and after that it is polished with *wetakeiya* or talipot leaf. They used *Ketayama katunwa* to engrave the design. Finally they obtained valuable creative art pieces by their incredible talents.

7.2 Designs, Materials and Technology

They were doing same processes and same techniques of Lac melting as mentioned before. They made *Lakada Kooru* out of *Puwak* wood. They used traditional decorations to carving, engraving and inlaying methods. *Galbindo* (diamond shaped spots), *Palapethi* (petal pattern), *Dela* (net pattern), *Patura* (elongated isosceles triangle) are decoration patterns that were commonly applied on the Lac objectives. Other than that they used traditional motives to embellish their products. *Hansaputtunwa* (pair of swings), *Bherunada pakshiya* (double headed eagle), *Gajasinghe* (elephant –lion), *Liyavela* (creeper) were used to decorate the Lac objects. Finally product was polished with talipot and *wetakeiya* leaf. Specially they produced products like, *Bastham* (stuffs), *Kodi-mitiya* (flag poles), *Hella –miti* (spear handle), *Pot Kamba* (Book covers).



Figure 7.2.1: Carving on Lac layer



Figure 7.2.2: Lac Product

8.0 Result and Discussions by Questionnaire survey

The main findings of this research identify six key factors in the order of the importance as, Introducing and developing new technology, Designs, Materials, Colour experimentation, conducting trainee programmes, and Teaching as a technical subject. These are the main factors that should to be considered to uplift the dying tradition of Lac craft in Sri Lanka.

In the traditional approach of applying Lac work uses three dimensional forms by roaring and pasting method. Other than that, it can be tested in the two dimensional forms, it can be changing turning and heating methods. It will be a new avenue for the traditional Lac craft. Design development is another fact that needs to be developed. Still Lac works have limited applications such as banner polls, boxes, book covers, walking sticks etc. But it can be explored rather than that accessories, jewellery, furniture items, and interiors as new trends. Design should be modified to cater to the present social needs and trends and it should be updated to set consumer preferences.

In past, several types of materials were used for Lac works. But in present it is limited to wood, but it should be explored to the other materials such as clay, ivory, clothes, horns, shells etc. It will help to add an additional benefit to the Lac craft in a modern way, as people like to buy new designs made out of new materials. Colour is a significant fact in Lac craft. They were using limited number of colours for *laksha* strips. As an experiment it can be changed by applying engraving and inlaying methods. And also the *tattugema* and *walakulgema* are new methods for color experimentation. The main reason to the low quality of the Lac is today lacquer work produce by the inferior method of painting the object and use varnish to get shine effect. It is a main threat for the workers who work in correct manner. Varnish products are sold in cheapest price and it competitively effect quality products. If it happens in long duration, future generation would not know about the quality of the Lac craft.

Another reason is that craft is not continued as before, because of attitudes of people. Because of that the methods and techniques are not transferred to the younger generations. In 1980 they won Vishwakarma award and president award in 1990. they have the talent but it not transferred to the younger generations. They have social issues; it is required to set their mind to re-generate the industry. If special workshops or trainee programmes can be arranged in villages, the youth could work together in a dynamic environment and share their ideas to set their mind.

Another finding is training as a technical subject. Sri Lanka has a new trend to reestablish traditional art and craft to enhance the Sri Lankan purity. It can be introduced to the school or university teaching level, and high education. It will be helpful to set the mind of the younger generations. Rather than that government solution conduct diploma or

trainee programmer to give opportunity. It would be helpful to set the mind of the younger and add some status to the craft people in the society.

In present it can be identified as a dilapidated craft, it should be preserved for the future generations as it has a traditional validity and traditional identity. It is required to be uplifted by identifying their weaknesses and their threats. It is important to introduce new technologies and designs, colour experiments, application of new materials by keeping its' traditional identity.



Figure 8.1: New Trends of Lac work
Source - Student Work

9.0 Conclusion and Recommendations

Lac craft is a valuable handicraft in Sri Lanka. It can be developed and protected for the future generation and it is a requirement of the current society. Hence this research has made an attempt to identify the prevailing situation of the Lac craft and areas which need to be developed to uplift Lac work tradition. It has been proved through this questionnaire survey and case study consequently identified six key factors, accordingly introduce and develop new technology, designs, materials, color experimentation, conduct trainee programme, and teaching as a technical subject are the main key factors that should to be developed to protect Lac craft. These criteria can be used to improve the quality of Lac work and to keep the dying tradition as a traditional craft. Achieving these key factors will help to reach to climax of the traditional Lac craft in Sri Lanka.

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A Study of Procurement Selection for Bridge Construction

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Abstract

Construction industry is pivotal part of any countries economy. Hence, the construction procurement selection is paramount important. This affects the successful and satisfactory completion and delivery of projects. In Sri Lanka, bridge construction is a key sector which contributes to the betterment of the construction industry and lends support to the growth of the economy. In addition, wrong selection of construction procurement approach usually leads to project failure, it is therefore very important to select the most suitable procurement system for bridge projects. The aim of this research is to address the selection of suitable construction procurement for bridge construction in Sri Lanka. The attempts were made through identifying and analyzing the factors which are highly influencing in the selection of a procurement system for bridge construction projects.

Through the comprehensive literature review and preliminary survey, twenty six factors were identified as factors influencing the selection of procurement system for bridge construction projects. A Survey research approach was adopted to investigate the research phenomena. The first round questionnaire survey was conducted with a view to identify the most significant factors affecting the selection of procurement system. From the first round of questionnaire survey, eleven factors were identified as most significant factors influencing the selection of procurement system by ranking the factors using Relative Important Index (RII) tool. The research found that accountability and transparency were the top most important factors which influencing the selection of procurement system for bridge construction.

Utility factors of available construction procurement systems for bridge sector against identified most significant factors were identified through the questionnaire survey round two by using RII tool. The importance and interrelationships of identified significant factors and utility factors provide a solid background for development of procurement selection criteria. The research recommended that the measure and pay system is the most appropriate procurement systems to procure the bridge construction projects through the developed utility model.

Keywords: Bridge Construction Procurement, Procurement Selection Parameters, Procurement System, Utility Factors.

1.0 INTRODUCTION

The construction industry is considered as the backbone of the economy of many countries. Generally, considerable amount of Gross Domestic Product (GDP) in developing countries is contributed by the construction industry, whereas the contribution of Sri Lanka is around 7% of GDP during last decade (Central Bank Report, 2010). According to De Silva and Rameezdeen (2002), construction industry recognized as an economic regulator, plays a major role in the economy, providing significant contribution to the national economy. The concept of procurement in such an influential industry has been defined in many ways. Cheung, Lam, Leung, and Wan (2001) revealed that the procurement is a key factor contributes to the project success as it determines overall structure of responsibilities and authorities of participants within the construction projects.

Construction projects are unique and each has its own characteristics. Different procurement systems are used for different types of projects and the correct choice may help to avoid conflicts and be the key to the attainment of project specific goals (Rameezdeen, & Rathnasabapathy, 2006). Conception is that the choice of an appropriate procurement system will lead to a successful project outcome; this makes an implicit assumption that the objective of a procurement system is to provide a successful project (Rowlinson & McDermott, 1999). Gamage (2005) stressed that it is much more important to identify factors affecting the procurement selection in advance for the choice of procurement system for particular project, because the conventional view of selection criteria is that it should be based around the concepts of time, cost and quality.

One of the major sectors of construction industry is infrastructure development such as roads and bridges. Infrastructure industry requires to be procured in a systematic way as it involves high cost, risk and complexity (Dharshana, 2010). According to Road Development Authority's (RDA's) statistics, there are 12165km of national roads including 4000m bridges within Sri Lanka (Road Development Authority, 2012). There are number of road rehabilitation projects and simultaneously bridge construction projects are on-going and as well as planned to complete in the near future. As the investment proportion is relatively significant as noted above, procurement in Sri Lankan bridge construction industry critically affects to the country's economy. Thus, procurement selection is critical. Prior to selection of procurement systems, it is an essential work to identify factors affecting the procurement selection. Those procurement selection parameters are very vital in selecting different types of procurement systems for bridge construction sectors. However, the procurement selection for bridge construction has not been still explored by the researchers under Sri Lankan context. Therefore, this research aimed at addressing the selection of suitable construction procurement for bridge construction in Sri Lanka. This will be achieved by identifying significant factors affecting procurement selection and determining the suitability of available procurement systems for bridge construction in Sri Lanka.

2.0 LITERATURE REVIEW

The term "Procurement" can be described simply as the way of getting things done. When moving to construction industry it is described the total process meeting the client's need for a building project (Brandon, 1999). According to Rathnasabapathy and Rameezdeen (2007) the procurement system is a key mean through which the client creates the pre-conditions for the successful achievement of project specific objectives. Hence, procurement is a key factor contributing to project success. It is hard to find a single procurement system which is suitable for all type of clients and all projects. Each project has its own characteristics and requirements. Therefore, different procurement systems are used for different projects (Rameezdeen, & Rathnasabapathy, 2006). If a client makes a wrong choice of procurement method, the penalty may be time and cost overrun and a general dissatisfaction. Therefore, the selection of the most suitable procurement method is critical for both clients and all other project participants. The appropriate selection may help to avoid problems and be the key to the attainment of project specific goals.

2.1 Construction Procurement Systems

Several types of construction procurement systems have been developed due to recent significant changes in the technical and economic conditions prevailing in the construction industry. Masterman (1992), Love, Earl, and Skitmore, 1998 and many authors have attempted to categorize procurement systems in many ways. The following Figure 2.1 shows the construction procurement systems practiced within the construction industry.

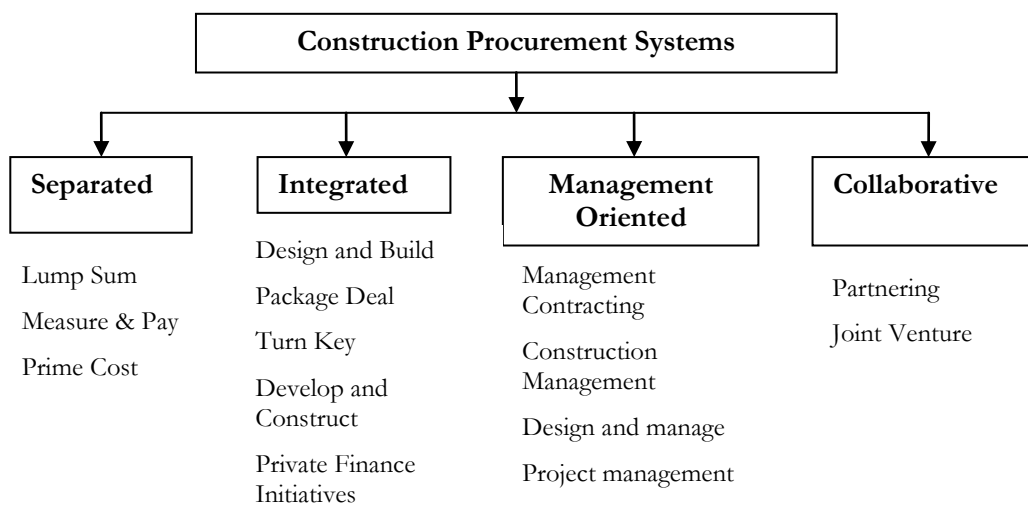


Figure 2.1: Categorization of Construction Procurement Systems (Source: De Silva & Rameezdeen, 2002)

2.2. Significance of the Sri Lankan Bridge Construction and Importance of Proper Procurement Selection

According to Hancher (2009), road and bridge sectors are perhaps the most conservative segment of the construction industry. Small improvements in this industry can result significant savings in time and cost, as well as better quality and fewer disputes. Bridge infrastructure plays a key role in the progress and economic growth of a nation, both through the direct effects of a higher mobility for citizens and goods and also via the indirect benefits derived from the process of building infrastructure. The positive economic impact of the bridge construction is that it is creating job opportunities, bringing business to local companies, and is benefiting the local resort community, which ultimately create impact on the entire country.

Roads and bridges infrastructure assets are drivers of economic development and social equity. They also have a significant impact on the natural and man-made environment. Transport system forms the backbone of local, regional, national, and international trade, making most economic activities critically dependent upon this resource. The infrastructure objects are complex engineering facilities and their construction and use require much special scientific knowledge (Dharshana, 2010).

The bridge replacement project will support the future widening of highway and has many features to ease traffic congestion and maritime movement in Roads, for many years to come. The whole island is benefited through the constructions of bridges by reducing travel time, vehicle operating cost and average speed of the vehicles. Further local people are also benefited. Project revenues are expected to be necessary to bridge the gap between total Project costs and available funds, and the toll revenues generated on the project could be sufficient to fill this gap. When considering the transport sector of Sri Lanka, the emphasis is always on roads and bridges. Thus these sectors are the backbone of the transport sector in the country. With 19 million people, Sri Lanka has a road network about 12,165 km of national roads (Classes A and B) including 4000m bridges. This network constitutes a vital component for the movement of people and goods and plays an important role in integrating the country, facilitating economic growth and ultimately reducing poverty (RDA, 2012). Therefore, huge bridge construction projects are to initiate in near future.

Hashim et al. (2006) argued that single procurement method is not suitable for every project since different projects have different characteristics. Thus, selecting an appropriate procurement system for bridge projects must be done in a careful manner than a building project. According to Masterman (1992), it should be done in a realistic, systematic and formalized way. Since bridge constructions have unique characteristics in their nature, factors which are significant in procurement selection for building construction may not significantly affect procurement selection of bridge construction. There may be separate set of significant factors affecting their procurement selection. Hence, identification of procurement selection parameters for bridge constructions is vital to select the most appropriate procurement system.

2.3 Procurement Selection Parameters - Conventional

From the client point of view, there are probably three basic concerns on his mind. These are cost, quality and time. Hence, traditional procurement selection processes result in prioritising the client's basic criteria of Time, Cost, and Quality (Seely, 1997). The basic idea of this is that, the client wanted the highest quality, at a lower cost in minimum time period. However, in most of the times this is not possible to achieve due to the fact that one or more requirements will suffer when trying to achieve one requirement (Bagnall, 1999).

Studies in the complex and competitive construction industry have identified several coherent Procurement Selection Parameters (PSPs). Since PSPs are crucial to procurement selection, accuracy of decisions generated from limited number of PSPs is in doubt. Therefore, only consideration of these three factors which lacks structured procedures based on good information may lead to unsuitable selection which ends with project failures (Luu, Ng, & Chen, 2003). Thus, considerations have to proceed beyond conventional parameters while selecting an appropriate procurement system for a construction project.

2.4 Procurement Selection Parameters - Broader

Construction industry is becoming more enthusiastic about the use of multifarious alternative construction procurement systems and choosing an appropriate method of procurement to satisfy the unique client and project requirements (Luu et al., 2003). There need be a clear basis to select the best procurement system. Researchers therefore argued for the development and application of a more systematic approach for procurement selection and the identification of appropriate PSPs as the first step of the selection process.

According to Ashworth (1996), factors affecting the procurement selection can be categorized under following four main categories.

- Client Requirements
 - Client Characteristics
 - Project Characteristics
 - External Environmental factors
- } Internal Environmental factors

2.4.1 Client Requirements

Construction projects are almost governed by the client and it is obvious that clients' requirements act as a major factor in the construction procurement selection. Turner (1990) argued that the procurement route that is most appropriate to the clients' requirements and priorities should arise from his or her own objectives and priorities. Therefore, it is an important task to identify the possible client requirements which affect the particular procurement selection prior to make decision on any procurement selection. Procurement selection parameters have been adopted by many researches over the construction industry during last decade. Through evaluation of previous studies conducted in this particular research area, the following client requirements were identified as most discussed factors.

- Speed of construction
- Price certainty
- Quality level
- Risk management
- Price competition
- Responsibility
- Disputes and arbitration
- Accountability and Transparency
- Time Availability and Predictability
- Familiarity

2.4.2 Client Characteristics

Client's characteristics govern their strategy in mobilising the project team and their attitude in dealing with risks (Luu et al., 2003). Further, Luu et al. (2003) highlighted seven client characteristics through their studies and emphasised that those should be taken into the consideration when selecting procurement system.

- Client type (Private/Public)
- Client's experience
- Client's in house technical capability
- Client's in house financial capability
- Client's willingness to take risks
- Client's willingness to be involved
- Client's trust towards other parties

2.4.3 Project Characteristics

Each construction project contains its' own unique characteristics. Therefore, every project is different from one another. Due to these unique characteristics most of the researchers have emphasized that project characteristic should be considered at the procurement selection. Luu et al. (2003) have identified seven project characteristics which include project type, project size, building construction type, project site location, unknown site risk factors, known site factors likely to cause problems and usage of pioneering technology. Alhazmi and McCaffer (2000) identified project type, project cost, time constraints, degree of flexibility, degree of complexity, payment method, design and construction integration and project funding method as the major characteristics that should be taken into account. Following project characteristic can be identified as the widely discussed factors to be considered in selection of the procurement system.

- Project type
- Project size
- Project cost
- Project site Location
- Project funding method
- Site risk factors
- Degree of flexibility
- Degree of complexity
- Time constraints
- Construction method

- Payment method of the project

2.4.4 External Environment Factors

Procurement selection process is an open system which receives information from its environment and returns it as output to the environment. Therefore, it is very important to know what forces from the environment drive the system and how these forces might change during the duration of the project life cycle (Rowlinson & McDermott, 1999). Luu et al. (2003) has identified 13 major external environment factors which affect to the construction procurement selection. Rowlinson and McDermott (1999) found out 10 major external environment factors affecting construction procurement selection. Following factors are the findings of those researches as the external environment factors which affects construction procurement selection.

- Market competitiveness
- Technology feasibility
- Regulatory feasibility
- Weather conditions
- Natural disaster
- Material availability
- Experienced contractor availability
- Industrial actions
- Institutional bodies
- Objection from neighbours
- Political constraints
- Cultural differences
- Finance for the project

3.0 RESEARCH METHODOLOGY

This research was carried out to identify the most significant factors affecting procurement selection and suitable procurement methods for bridge construction in Sri Lanka. Thus, it was essential to think of an appropriate research process, which is competent of identification of procurement selection parameters governing the bridge construction in Sri Lanka. Further, a proper research process can minimize the errors during the research and can reduce the mistakes that can be done by the researcher.

The current study adopted a survey research approach to investigate the research phenomena. Using convenience sampling technique, the samples for the current study were selected from the professionals in employer, consultant and contractor organizations who have implemented or being implementing class A and B bridge construction projects within Sri Lanka. Sample size must be high enough to avoid sampling errors. The sample selected for this study was 34 and the responses obtained were 30. It consists twelve respondents representing employer and another eighteen respondents representing consultant and contractor organizations.

The questionnaire survey was started from a pilot survey which was carried out to ensure the reliability of the survey. Five experts from bridge sector procurement were involved in this task and their feedbacks were used to fine-tune the format of the questionnaire. The questionnaire survey round one was prepared in order to explore the significant procurement selection parameters related to bridge construction projects. Commonly practiced procurement methods in Sri Lanka and the most significant factors influencing in selection of procurement method identified in the questionnaire round one were used to prepare the second questionnaire. Those most significant eleven factors identified out of 26 factors included in questionnaire round one have been considered against four commonly used procurement methods in bridge construction to identify the utility of procurement methods.

Collected data from questionnaires survey had been evaluated systematically to achieve a proper answer to the research question. The research aims to rank the Procurement Selection Parameters (PSPs) governing bridge construction procurement selection relatively to the importance of other available PSPs. Thus, Relative Important Index (RII) was used as the tool for the analysis. Therefore, likert scale was used in questionnaire survey. Reliability was measured by calculating Cronbach's alpha using SPSS software.

4.0 RESEARCH FINDINGS AND DISCUSSION

The data were collected from various construction professionals in two different phases through two sets of different questionnaires. The questionnaire one was developed using procurement selection parameters identified through the literature survey and preliminary survey and Questionnaire two was developed based upon the findings from all of the distributed and completed questionnaires at round one. The questionnaire one comprised twenty six PSPs which

consists ten parameters from client requirements, eight parameters from project characteristics and eight parameters from external environment factors.

The respondents were asked to indicate the significance of those PSP's in the 1-5 likert scale according to their individual view to select procurement method for the particular bridge project which they refer. Gathered data had been analysed using RII tool to obtain the RII values of each parameter. Then parameters were ranked according to the RII value of the each parameter. In order to ensure the reliability of the data used, Cronbach's alpha had been calculated for the data.

The PSPs which are having RII value more than 75% as per the overall perspective were taken as the most significant procurement selection parameters for bridge construction in Sri Lanka. They had been extracted and presented as shown in the Table 4.1. This identification of most significant PSPs was the main aim of this research.

Table 4.1: RII values and rankings of PSPs – Overall Perspective

No.	Procurement Selection Parameter (PSP)	RII	Rank
Client Requirements			
1	Price Competition	82.67	4
2	Price certainty	72.67	12
3	Quality of work	86.67	2
4	Risk management	80.00	8
5	Responsibility	69.33	15
6	Disputes and arbitration	54.67	24
7	Speed of construction	71.33	13
8	Accountability & transparency	89.33	1
9	Time availability & predictability	82.00	5
10	Familiarity (Client's awareness of procurement system)	79.33	9
Project Characteristics			
11	Project type	70.00	14
12	Estimated project cost	68.00	16
13	Project funding method	83.33	3
14	Site risk factors	64.00	18
15	Degree of flexibility	80.67	6
16	Degree of complexity	80.67	6
17	Time constraints	79.33	9
18	Payment method of the project	77.33	11
External Environment Factors			
19	Market competitiveness	51.33	26
20	Technology feasibility	63.33	19
21	Regulatory feasibility	57.33	22
22	Weather condition/ Natural disaster	58.67	21
23	Resource availability	62.67	20
24	Objection from neighbour/Public	55.33	23
25	Political constraints	54.67	24
26	Finance for the project	68.00	16

Overall perspective of the bridge construction industry had been observed by analysing the data from employer (RDA) and other parties' together. Most significant PSPs have been highlighted in the above Table 4.1. Altogether eleven

factors has been identified as the most significant PSPs. Six out of those eleven PSPs represent client requirements while five represent project characteristics and none represents external environment.

4.1 Utility Factors of Most Significant PSPs

Questionnaire two had been developed by considering the above stated most significant procurement selection parameters in order to find the utility of current procurement methods against these PSPs. It is pointless to assess the suitability of procurement methods which are not used in bridge construction projects in Sri Lankan context. Thus, it has been selected only the procurement methods which have been observed through the questionnaire round one. The procurement methods used in questionnaire one have been identified through the literature survey as used for bridge projects in many countries around the world. The questionnaire two has been used to assess the suitability of these procurement methods to Sri Lankan context.

The questionnaire had been distributed among the respondents of questionnaire round one. They were asked to indicate the extent of suitability of each procurement method stated in the questionnaire to meet or support the stated procurement selection parameters in the 1-5 likert scale. Data which were collected through the questionnaire two also had been analysed using the RII tool. The result observed through the analysis is shown in the below Table 4.2. Observed RII values of each PSP against the particular procurement method had been considered as the utility factor values of those PSPs against the particular procurement method.

Table 4.2: Utility factors of most significant PSPs for bridge construction projects in Sri Lankan context.

Procurement Selection Parameter (PSP)		Traditional System - Lump Sum	Traditional System - Measure & Pay	Design & Build	Turnkey
1	Accountability & transparency	76.67	85.33	53.33	64.00
2	Quality of work	70.00	71.33	65.33	74.67
3	Project funding method	80.00	64.67	71.33	67.33
4	Price Competition	78.00	86.00	62.67	60.67
5	Time availability & predictability	51.33	67.33	80.00	61.33
6	Degree of complexity	50.00	61.33	71.33	74.00
7	Degree of flexibility	40.67	84.00	57.33	55.33
8	Risk management	81.33	64.67	74.67	70.00
9	Time constraints	58.67	55.33	80.67	70.67
10	Familiarity(Client's awareness of procurement system)	64.00	87.33	75.33	58.00
11	Payment method of the project	70.00	81.33	72.00	59.33

4.2 Usage of Utility Factors

Above identified utility factors had been obtained considering the overall bridge construction in Sri Lanka. Therefore, they can be successfully used at procurement selection process for bridge construction in Sri Lankan context. When selecting a procurement method for a particular bridge project, first step is to rank the identified most significant eleven PSPs as per priority. Then rank number one may assign weight of eleven. Rank number two may assign weight of ten. Accordingly rank number eleven may assign weight of one. Then the utility value of each PSP against particular procurement method shall be multiplied with weight assigned to the PSP and the weighted utility factor value shall be calculated. Finally weighted utility factor values related to each procurement method shall be added together. The procurement method which possesses the highest weighted utility value is the most suitable procurement method for that particular bridge project according to the priorities and this utility value model. Traditional system using measure and pay was identified as the most appropriate procurement method to procure the bridge construction projects through the developed utility value model as shown in the below Table 4.3.

Table 4.3: Usage of utility value model.

No	Procurement Selection Parameters	Weight	Traditional System - Lump sum		Traditional System - Measure & Pay		Design & Build		Turnkey	
			UF %	WUFV	UF %	WUFV	UF %	WUFV	UF %	WUFV
1	Accountability & transparency	11	76.67	8.43	85.33	9.39	53.33	5.87	64.00	7.04
2	Quality of work	10	70.00	7.00	71.33	7.13	65.33	6.53	74.67	7.47
3	Project funding method	9	80.00	7.20	64.67	5.82	71.33	6.42	67.33	6.06
4	Price Competition	8	78.00	6.24	86.00	6.88	62.67	5.01	60.67	4.85
5	Time availability & predictability	7	51.33	3.59	67.33	4.71	80.00	5.60	61.33	4.29
6	Degree of complexity	6	50.00	3.00	61.33	3.68	71.33	4.28	74.00	4.44
7	Degree of flexibility	5	40.67	2.03	84.00	4.20	57.33	2.87	55.33	2.77
8	Risk management	4	81.33	3.25	64.67	2.59	74.67	2.99	70.00	2.80
9	Time constraints	3	58.67	1.76	55.33	1.66	80.67	2.42	70.67	2.12
10	Familiarity(Client's awareness of procurement system)	2	64.00	1.28	87.33	1.75	75.33	1.51	58.00	1.16
11	Payment method of the project	1	70.00	0.70	81.33	0.81	72.00	0.72	59.33	0.59
				44.49		48.62		44.21		43.59

UF Utility Factors
WUFV Weighted Utility Factor Value

According to the Table 4.1: RII values and rankings of PSPs, accountability and transparency is identified as the most critical factor which influencing selection of procurement method for bridge projects in Sri Lanka. In relation to Table 4.3; Utility value model, traditional using measure and pay got the highest WUFV of 9.39 and design and build got the least WUFV of 5.87 for accountability and transparency. This seems that traditional procurement method has high accountability and transparency compared to other methods. This could be because; in Sri Lanka RDA is the major client who is a public authority. Therefore, accountability and transparency have been identified as the most important PSP and the D&B and Turnkey are poor in terms of satisfying this PSP.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The construction industry is one of the major industries in all the countries. This critically affects to the countries' economy. Thus, construction procurement selection has been one of the major research areas in current practice. The existing literature have pointed out the importance of developing more systematic approach in procurement selection process for any specific project and identification of appropriate Procurement Selection Parameters (PSPs) to formalize the selection process.

Bridge construction is one of the dominant sectors contributing to the construction industry in Sri Lanka. Hence, procurement selection in bridge construction projects critically affects to the country's economy. Identification of Procurement Selection Parameters (PSPs) relating to bridge constructions is the first step to formalize the selection process.

As the first step identification of the influencing factors in procurement selection from the perspectives of clients' requirements, project characteristics and external environment factors was achieved through a comprehensive literature review. Then, quantitative research approach based questionnaire survey has been used for this research in order to identify the most significant PSPs governing bridge construction procurement selection. Collected data from questionnaire survey had been evaluated systematically using Relative Important Index (RII) to achieve proper answer to the research question. PSPs were ranked according to their RII values. According to the results following are the most significant parameters which are affecting the procurement selection for bridge construction in Sri Lankan context.

Table 5.1: Most significant factors affecting procurement selection for bridge construction in Sri Lanka

Procurement Selection Parameter (PSP)	Rank
Accountability and transparency	1
Quality of work	2
Funding method	3
Price competition	4
Time availability and predictability	5
Degree of complexity	6
Degree of Flexibility	6
Risk management	8
Time constraints	9
Familiarity (Client's awareness of procurement system)	10
Payment method of the project	11

Accountability and transparency is the top most significant parameter to be considered at procurement selection for bridge construction projects according to the overall perspective of the bridge construction industry in Sri Lanka.

Further, the results of this analysis indicated that although various procurement methods exist, still traditional measure and pay system is the ruling procurement method in the Sri Lankan bridge construction industry. Without limiting to the above results, this research study extended to find the utility factors of above identified most significant procurement selection parameters against the procurement methods used for bridge construction projects in Sri Lanka through the second round of questionnaire survey. The findings revealed that traditional system using measure and pay method has the highest utility with five PSPs while traditional lump sum method, design and build method and turnkey have highest utility with two PSPs. The procurement method which possesses the highest weighted utility factor value shall be taken as the most suitable procurement method for that particular bridge project according to the priorities and this utility value model.

The research recommends that the Sri Lankan economy would be enhanced through infrastructure development. As a first step, this could be achieved by selecting the most suitable procurement method considering the factors influencing the procurement selection. Further the study suggests that the industry should move towards new procurement trends for bridge construction projects to procure the projects in a systematic way which leads to project success in terms of cost, time, quality, public health and safety.

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Colour as a Tool to Manipulate Indoor Thermal Perception in Tropical Upland Climate; A Field Experiment Implemented in Sri Lanka

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Abstract

Incorporating warm colours in the interiors of tropical uplands characterised by a cold climatic condition, was hypothesised to help the inhabitants to perceive the indoor thermal environment as comparatively warmer, compensating the heating costs to a considerable extent.

A preliminary field experiment was executed to investigate the impact of a warm colour (red - Cranberry Zing) and a cool colour (Duck egg blue) on indoor thermal perception in tropical upland climate with reference to Thalawakele, Sri Lanka.

Substantiating the hypothesis, participants consistently perceived the red room to be comparatively warmer (90% - warm and 10% - slightly warm) while the blue room was perceived to be even cooler by 93.5% (64.5% - cool/ 29% - slightly cool) and neutral by 6.5%. Ability of red colour to induce a comparatively warm 'perceived' indoor thermal condition against the 'real' thermal condition in tropical upland climate could be potentially developed as an alternative hybrid remedy for energy conservation.

Keywords: *Thermal perception, Warm colours, cool colours, tropical upland climate, Energy conservation.*

1. Background

This is an era where innovative architectural and design interventions that focus on energy conservation have been given a greater emphasis. Amidst the diverse attempts made in innovative architectural, planning and interior design solutions aiming to cut down heating and cooling costs, starting from the orientation of the building itself to the use of passive solar design strategies, construction methods and incorporating appropriate building materials and finishes, the current investigation focuses on a simple, low cost solution.

Colours are known to play many roles in the paradigms of Architecture and Design. They have widely been used for aesthetic and visual purposes in built environments to create pleasing harmonious compositions. It has also been a usual practice to integrate the ability of colour to alter the perceived dimensions of space and objects. However, revealing another dimension of it, colour has been explained by scholars, researchers and colour therapists as to influencing thoughts, feelings, emotions and behavior. Usage of this property of color is evolving beyond its typical aesthetic value, to aid human performance corresponding to the intended activity of built spaces. Amongst diverse colour associations, the current study focuses on the ability of colour to alter human thermal perception, as a means of energy conservation.

At this juncture, it is vital to clarify that the study does not focus on the heat absorbing / heat reflecting properties of colour, which are already used as a strategy to conserve energy. As per the principles of colour theory, light colours will reflect more heat and dark colours will absorb more heat; thus, the lighter the colour, the higher will be the reflectivity of a surface. Accordingly, while white has the highest light reflectance value (LRV), black is known as the best absorbent. For instant, white reflects 80% of light, whereas black will reflect only 5%. This principle has been applied to manipulate and conserve energy to be spent on interior lighting. For instance, the higher the LRV number of the paint colour, the lesser will be the amount of artificial light needed (Morton, 2012). To be explicit, far more lighting is required for rooms with dark walls than for those with light walls and the cost of energy involved will be high. In addition to the walls, keeping the ceiling light and bright will increase reflectance to support energy conservation. Similarly, light colours applied on roofs are said to cut down cooling costs of interiors due to their high albedo. Morton

(2012) describes a study conducted in Austin, Texas on a clear, sunny day having an outdoor temperature of 90 ° F (32.2 C), where a white roof had a temperature of 110 ° F (43.3 C), an aluminum coated roof, 140 ° F / 60 C, while a black, single ply roof, a temperature of almost 190 ° F / 87.8 C. As further highlighted by Morton (2012), another study in Florida revealed that by increasing heat reflectivity, homeowners saved an average of 23% of their cooling costs. Accordingly, the LRV value of a coloured surface has been established as a decisive factor for energy conservation. The current study focuses on a different aspect of colour, potentially conducive for energy conservation; the ability of colour to alter the perceived temperature.

1.1 Supportive Literature

Mahnke (1996) states that colour can be identified in terms of temperature. As explained by Candas and Dufour (2005), thermal perception could be created by the visual appearance or the colour of an object. Moseley and Arntz (2007) explain that colours have the power to endorse an implicit meaningful association in relation to temperature; typically, red is linked to “hot” while blue to “cold”.



Figure 1: Warm cool division in the Colour Wheel

Traditional colour theory distinctively differentiates between warm colours and cool colours to have opposite psychophysiological impacts upon humans. Red, orange and yellow are identified as warm colours which are stimulating, while blue, green and purple are referred to as cool colours with pacifying effect on human beings (Stone 2001, Ballast 2002).

Compared to the research conducted on diverse colour associations, scientifically or statistically substantiated research data on the nature of colour associated thermal perception is inconclusive. In his book “Colour environment and human response”, Mahnke (1996) explains the warm/cool perception of colour as a synesthetic response; the unity between two different sensory modalities. This simply suggests that every sense is linked with each other. Moreover, he explains that colour perception is simultaneously linked with other perception modalities such as weight, volume, size, temperature, noise, sound, etc. As suggested by Mahnke (1996), colour has the power to suggest warmth or coolness as a manifestation of a synesthetic response.

On the other hand principles of colour therapy explains the possibility of colour in altering human body temperature as a result of a metaphysical reaction. This is considered as a possible reason for the perception of certain colours as warm and vice versa. For instance, while Manuel (2011) suggests that colour red can increase one’s energy level and raise the body temperature, Lung (2011) proposes that the colour blue lowers the pulse rate and decreases body temperature. In a recent study, Hettiarachchi (2014) investigated the logic behind colour associated thermal perception with reference to colours red and blue in a controlled laboratory environment (26°C/ 50% rh /350 lux). This study revealed that psychological parameters were statistically significant against the parameters of actual thermal sensation and core body temperature. Mahnke (1996) mentions that people are found to be fairly unanimous in their opinion of warm/cool perception regardless of how it takes place.

Scholars who have attempted to provide scientific evidence for theory of warm and cool colours are minimal. Mahnke (1996), the president of international colour association, has cited a few previous researchers who have provided supportive evidence for the perception of colour in terms of temperature. A study done by Johns Itten (1961, cited in Mahnke, 1996) demonstrated a difference of 5 - 7 degrees in the subjective feeling of heat or cold between a workroom

painted blue-green and one painted red- orange. Occupants of the blue-green room felt 59 ° F as cold, whereas the temperature had to fall to 52 ° F in the red- orange room before the subjects felt cold. Clerk (1975) reported that employees complained of the coldness in an air-conditioned factory cafeteria with light- blue walls, although the thermostat was set at 75 ° F. The walls were repainted orange and the 75 ° F temperature setting, then considered too warm, was reduced to 72 ° F. In a Norwegian study, subjects tended to set the thermostat 4 degrees higher in a blue room than in a red room (Tom and Micelles, 1976). Further strengthening this ideology, Morton (2012) reports on tests in which people estimate the temperature of a room with cool colours, such as blues and greens, to be 6 -10 ° F cooler than the actual temperature. Warm colours, such as reds and oranges, will result in a 6-10 ° F warmer estimate. Accordingly, a few scholars have yielded supportive evidence for the ability of colours to alter thermal perception of an interior.

However, as identified by Gage (1995), the usage of colour associated temperature in prescribing colours have always been a matter of debate and puzzlement. The lack of knowledge on the nature of manifestation and the contributing factors of colour associated thermal perception are the main causes of obstruction in its effective integration to man-made environments.

Going in line with the few supportive findings, the current study attempts to seek the possibility of integrating colour as a tool to conserve energy in cool climatic regions. A recent investigation executed by Hettiarachchi (2014), revealing this association to be a psychological reaction, firmly suggested the potential of the warm cool dichotomy of colour perception to be integrated in the built environment to 'psychologically manipulate the occupant's perceived thermal milieu against the actual thermal conditions', which could eventually contribute as an alternative remedy for energy conservation. Consequently, the research design of the current investigation was formulated based on the principle that the perception of warm/cool colours is a psychological reaction.

Building interiors are mostly designed integrating warm colours as an influence of the traditional British practice, molded and fashioned by cold climatic conditions. In fact, the inhabitants of Britain, by default, demand warm colours in their interiors and reject cool colours (Perera, K, personal communication, July 8, 2014). Even though not established in literature, this provides inspiration for an unconscious psychological response, accumulated throughout the course of time and converted into a practice to counteract the cold climatic conditions, using the perceived thermal aspect of colour where a psychological thermal comfort is achieved. As mentioned by Mateeva, 2011, it may be expected that people with long-lasting adaptations to hot climates have lower sensitivity to them and higher sensitivity to cold climates, and vice versa – people durably adapted to cold climates have lower sensitivity to them and higher sensitivity to warm climatic conditions. Accordingly, it can be proposed that the inhabitants of cool climatic regions could prefer the stimulating, warm psychological impact of warm colours against the cool, pacifying impact of cool colours and very sensitive/ responsive towards warm colours.

To highlight a parallel approach, Albers et al (2013) attempted to test colour in the form of light; warm/cool coloured LED lighting scenarios to conserve energy in the aircraft/aviation industry. Subjects reported slightly warmer thermal sensations in yellow light and slightly colder sensations in blue light demonstrating a slightly higher level of satisfaction with the climatic situation in yellow light. As revealed by Albers et al (2013), even though the impact of lighting on temperature and comfort sensation is minimal, large scale utilization could potentially contribute to a quantifiable impact on energy savings. Similar impacts could be anticipated by the integration of colour in the applied form (paints/pigments). Supportively, Morton (2012) has suggested that "Colour does play an important role in energy conservation".

1.2 Hypothesis

The current study hypothesized that warm colours (red), integrated in interiors of cold climatic regions, will make the inhabitants perceive the interior as warmer than the actual thermal condition, while cool colours (blue) in the same interiors will make them feel even cold.

1.3 Aims and objectives

This research attempted to test the above hypothesis via a field investigation. The findings of the study can be helpful on one hand to architects, interior designers, and landscape designers, interested in methods of improving thermal comfort of interiors in cold climatic environments. On the other hand, this will provide insight to recognize colour as another factor which should be considered in the process of formulating energy efficient design strategies. For instance, it is expected here that warmer thermal perception, psychologically induced by a warm colour may compensate the energy to be spent on heating the interior to some extent; a hybrid remedy for energy conservation.

2. Method

Personalized houses possess familiar spaces of human beings, to which they are highly sensitive than any other space. Therefore, the simplest alteration done in one's own home may have a great impact on his/her perceptions and psychophysiological responses. An alteration in one's most personal space such as the bedroom may have a predictable impact on its user in this regard. Accordingly, the design of the current field investigation was focused on altering the colours of bedrooms to test the impact on thermal perception. Talawakele, a town located in the Nuwara Eliya district of the central province of Sri Lanka was selected (mean annual temperature -18°C) representing the tropical upland climate characterized by a comparatively cold thermal condition.



Figure 2: Location of selected houses
-Google map – Upper Kothmale hydropower
project Housing scheme



Figure 3: View - Upper kothmale
hydropower project Housing
scheme

2.1 Research Design



Figure 4: View of a sample house (Figure: 5) while the other three walls were proposed to be painted in brilliant white (Figure: 7, 8, 9). This decision ensured that the two rooms to be tested are identical in every aspect other than the introduced red or blue colour.

A sample of 7 nos of identical houses from a housing scheme having the same plan and identical method of construction, materials and finishes constructed under the upper Kothmale hydropower project were selected to execute this field investigation. Being adjoining houses located in the same locality all the climatic factors; solar radiation, outdoor temperature, humidity and air velocity pattern remained same. In these selected seven houses there were 31 participants of varying age groups representing both genders (17 males and 14 females). Two identical bedrooms having the same dimensions, and fenestrations (a door and a window in each) were selected to apply the colour. The colours to be tested were proposed to be applied on an identical wall per room; a warm colour on one wall and a cool colour on the other

2.2 Colour Selection and application

A red hue was proposed to be tested as the warm colour based on the stimulating effect of the colour identified in theory of colour. Even though red in its full intensity will induce the greatest impact, considering the ethical fact that this colour is to be applied in a house occupied by human beings, and the new colour scheme is proposed to be remained unchanged until the next colour wash to be done by the occupant, a de-intensified version of red (*Cranberry Zing*) was specified. On the other hand, being the most recognized colour representing the cool paradigm of the colour wheel, a blue hue was proposed to be tested. Considering the accepted cooling and sedating effect of the colour found in colour theory, despite using blue hue in its full intensity a de-intensified version of blue was selected from the colour manufacturer (*Duck Egg Blue*). The specified colours were shown to the respective house owners and their consent was obtained prior to the application, fulfilling ethical concerns.

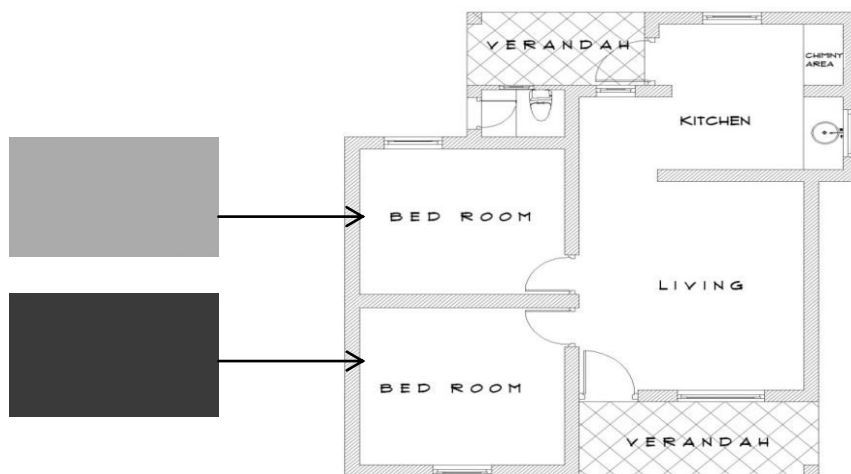


Figure 5 - Layout of a house

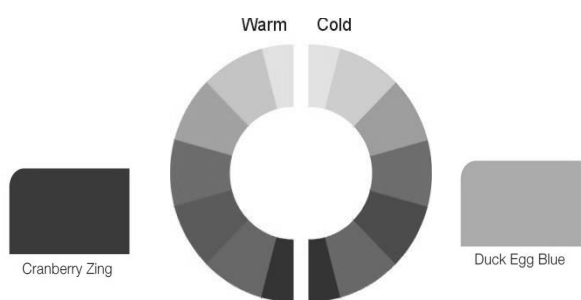


Figure 6: Colours specified to represent the warm and cool paradigms of the colour wheel



Figure 7: Cranberry Zing, brilliant white and duck egg blue before application



Figure 8 - Colour application process

Precise instructions on the colour application process were provided to the house owners and, all the seven houses were coloured simultaneously with their involvement under the supervision of the investigator. This can be identified as a win-win situation where these seven houses were painted free of charge.

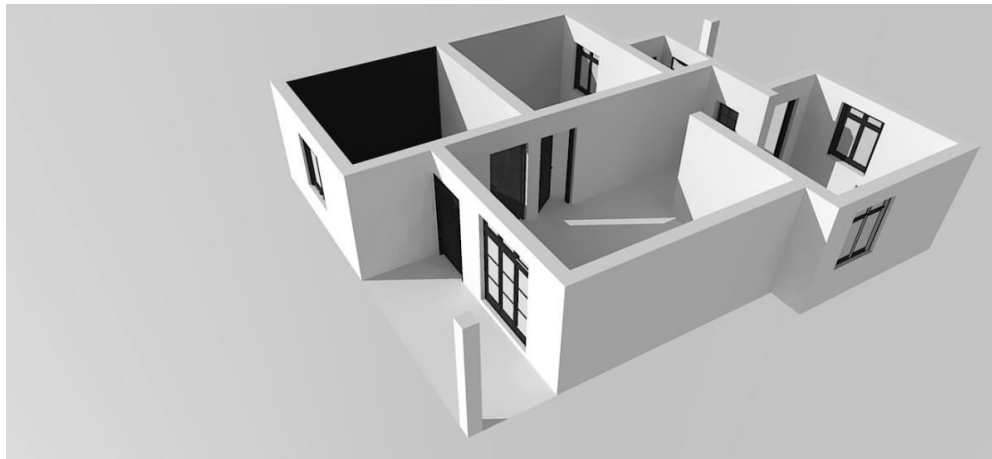


Figure 9 – 3D view of the identical bedrooms after colour application

2.4 Data collection

At the onset of the investigation, favorite colour/colours of the participants of each house were inquired to test the possible impact of long term exposure to a cold climatic condition on colour preference. It was expected here that, residents in a cool climatic region might prefer warm colours against cool colours due to its perceived warm thermal impacts.

Once the new colour scheme was applied, the subjects were requested to occupy the rooms for 24 hours to follow their normal routine while getting exposed to the new colour scheme. Following the new colour exposure, the subjects were interviewed to identify their general response; attitude, feelings emotions towards the new scheme and the effect of red/blue colours on their thermal perception of the interior.

The main data collected was the possible difference of thermal perception of subjects associated with new colour scheme with reference to the two bedrooms; red room and blue room. The subjective perceptions were transformed into objective data with the use of a 5 point likert scale which is a reduced version of the PMV scale (Fanger, 1970).



Figure 10: Likert- scale questions Source: PMV scale (Fanger, 1970)

The indoor temperature of red vs blue rooms in all the 7 houses against outdoor temperature were monitored via a digital thermometer.

3. Results and Discussion

Research findings revealed by the questionnaire are graphically presented below.

3.1 Favourite colour

Question answered: What is your favorite colour? (Blue, Red, Green, Yellow, Purple, pink, white, black.....)
Other suggestions if any.....

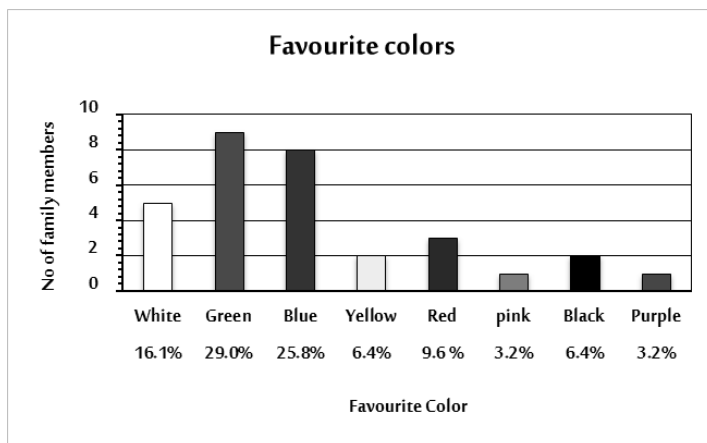


Chart 1 – colour preference

Note: The majority (58%) selected cool colours (Green, blue and purple) as their favorite colours while 22.5% liked neutral colours (Black and white) and only 19.2% selected warm colours (Red, yellow and pink) as their favourite colours.

3.2: Perception of new colour scheme vs. Previous colour scheme

Question answered: Did you feel any difference between the new colour scheme and the previous colour scheme? (Yes / No / Neither) Other suggestions if any.....

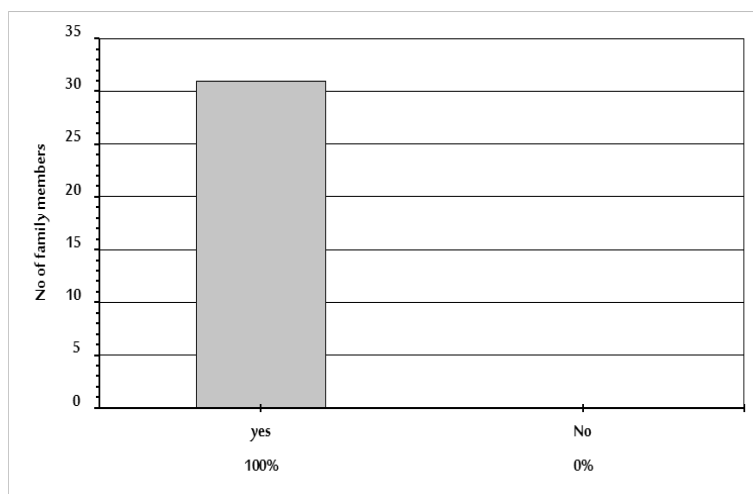


Chart 2: Perception of new colour scheme vs. Previous colour scheme

Note: 100% perceived a difference between the previous and the new colour schemes.

3.3 Type of the perceived difference between new and the previous colour scheme

Question answered: What type of a difference did you feel from the new colour scheme? (Positive, neither positive nor negative, negative)

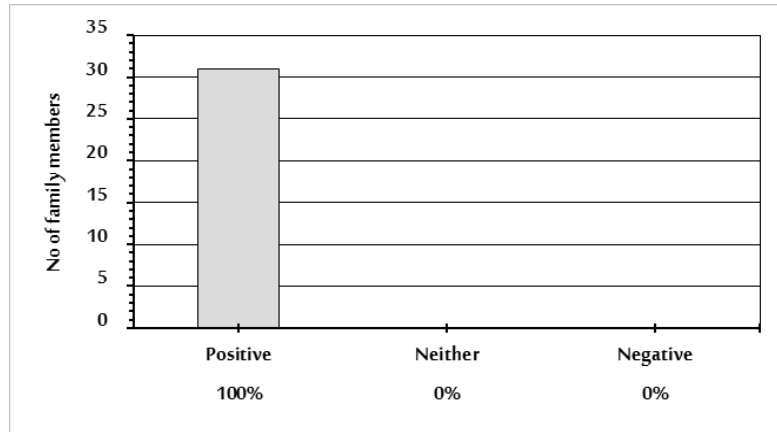


Chart 3: Perception of new colour scheme vs. Previous colour scheme
 Note: 100% were positive with new colour scheme.

3.4 Spontaneous thermal perception in general

Question answered: Did you feel any variation in thermal perception associated with the new colour scheme? (Strongly agree /agree/ neither/ Disagree/Strongly disagree) Other suggestions if any.....

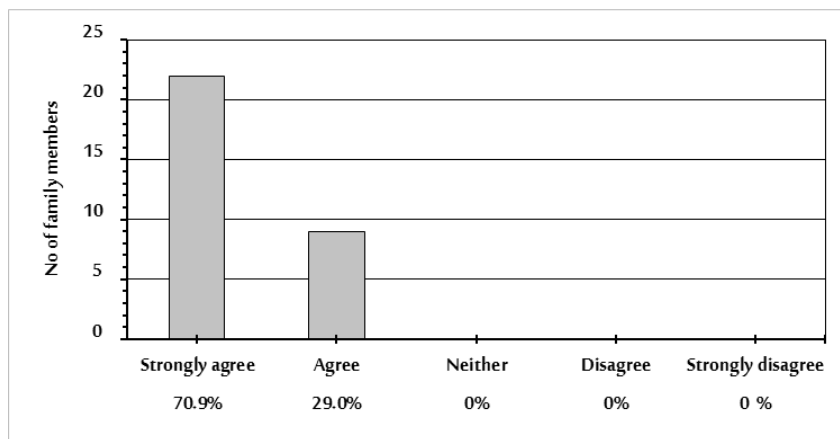


Chart 4: Spontaneous thermal perception in general
 Note: Being on par with hypothesis, majority (99.9%) regardless of the variations of age and gender felt a thermal perception variation in new colour scheme against the previous. Most of them agreed (99.9%) that they felt a difference in room temperature especially during the night time.

3.5 Thermal perception associated with red (Cranberry Zing) room.

Question answered: Describe your thermal perception in the red colored room?
 (Warm / slightly warm / neutral / slightly cool / Cool)

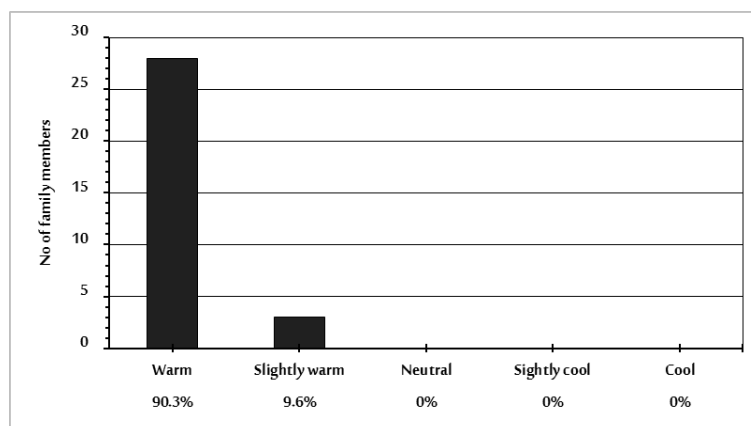


Chart 5: Spontaneous thermal perception in general

Note: A majority (99.9%) of participants perceived red room to be warmer (90.3% strongly agreed and 9.6% agreed). None of them perceived it to be cooler.

Few noteworthy comments made by the participants of the seven houses on the impact of colour red in general and associated thermal perception are quoted below.

A young boy (18 yrs.) of house two – *“I feel that my bed room is warmer than what I felt before due to the introduction of red colour”*

A boy (13 years) of house five – *“I slept well than previously in my red coloured bed room, because of its warmth”*

Old person (64 years) in house four – *“I got muted when I saw the red room at once”*

A lady (42 years) of house six (a Hindu family) – *“We like red coloured room as red is very much closer to our religion”*

On the other hand as a significant finding, the participants highly preferred the red room suggesting their sensitivity to colour red.

3.6 Thermal perception associated with blue (duck egg blue) room.

Question answered: Describe your thermal perception in the red colored room? (Warm / slightly warm / neutral / slightly cool / Cool)

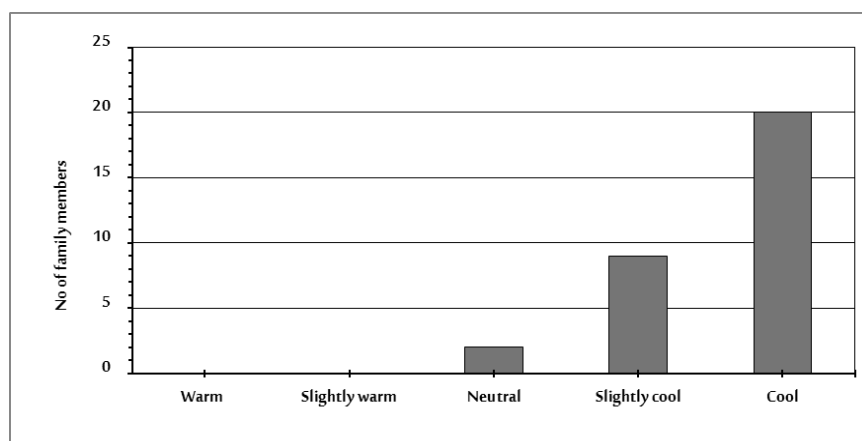


Chart 6: Spontaneous thermal perception in general

Note: A majority (93.5%) perceived blue to be cool (64.5% strongly agreed, 29% agreed) and 6.4% remained neutral. None of them perceived the room to be warm.

Two interesting points which the author noted among the comments made on the impact of colour blue in general and on thermal perception are attached below.

A young girl (20 yrs.) in house two – *“I felt very uncomfortable last night in blue room, because it ‘was very cold than previous days.”*

A lady (59 yrs.) in house two – *“Blue is a beautiful colour, but I like red coloured interior”*

Accordingly preference to the blue room was less compared to the red room.

3.6. Preference comparison - Cranberry Zing room vs. Duck egg blue room.

What is the room that you prefer most in terms of the colour scheme?
(Cranberry Zing room/. Duck egg blue room)

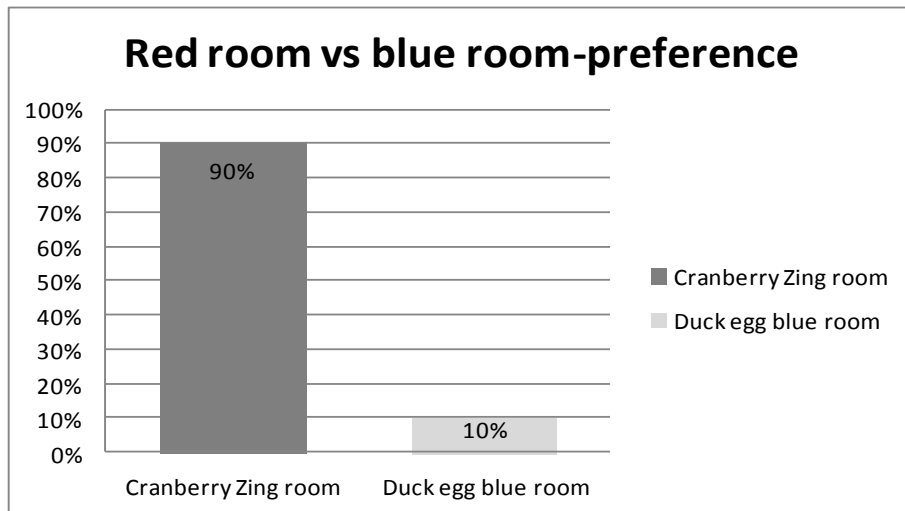
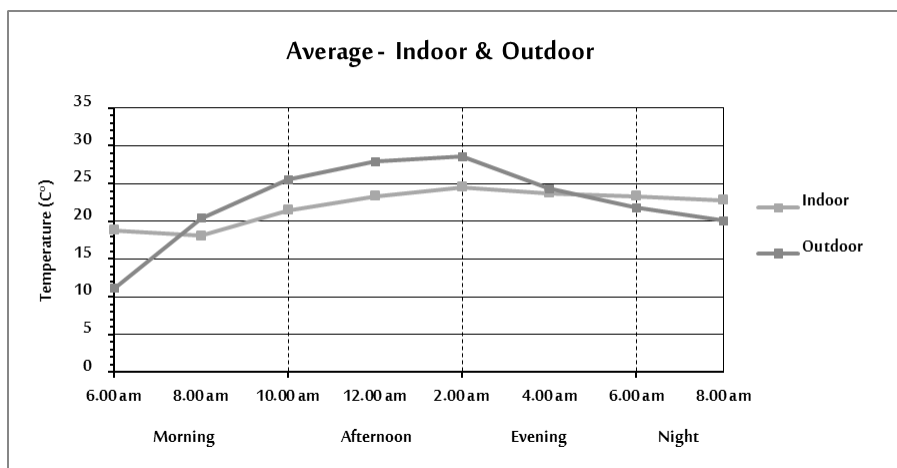


Chart 7: Preference – Red room vs Blue room

Note: The majority of participants preferred the red room most (90%) whereas only 10% preferred the blue room.

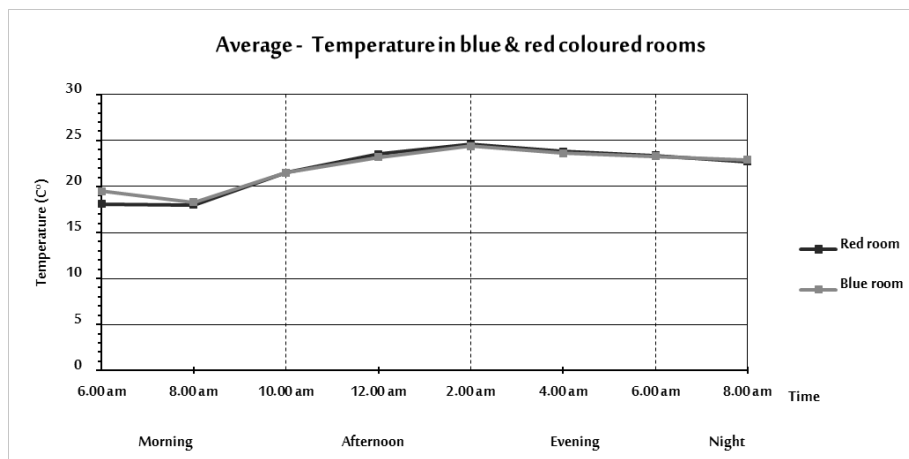
3.7 Average indoor and outdoor temperature.

Note: The indoor temperature was found to be higher than outdoor temperature in the morning while the extreme opposite reaction was reported during the day time. As shown in the graph below, indoor temperature increased gradually while the outside temperature decreased rapidly with the night fall.



Graph 1 – Average indoor / outdoor temperature

3.8 Average temperature of blue and red coloured rooms



Graph 2 – Average temperature red vs blue

Note; No significant difference between the indoor temperature of rooms having a red wall and a blue wall was reported even though the inhabitants perceived red room as warm and blue room as cold.

4. Analysis and Conclusions

When it comes to the colour preference of the participants, it was revealed that cool colours were dominating as their favorite colours (58.0% - green, blue and purple) while 22.5% selected neutral colours (black and white) and only 19.2% selected warm colours (Red, Yellow and Pink) as their favorite colours. Warm colours were not dominating as their favorites as anticipated by the investigator. This preference to some extent can be as a result of long term psychophysiological adaptation, acclimatization and familiarization to a cold climatic condition characterized by a cool pacifying ambience.

All the participants of the seven houses involved (100%) were positively responding to the new colours in their bed rooms. This however could be explained as a common psychological reaction to a new change applied within a long existing situation, especially in terms of a colour scheme. However considering their personal comments as well as the spontaneous reactions triggered by the two new colour schemes applied, it was revealed that even though a majority possess a cool favorite colour, they were much sensitive and responsive to red room against blue room (Red - 90%, Blue – 10%). They remarkably preferred red room and showed a lesser interest on the blue room. As the underlying reason for this finding, it can be suggested that people who are psychophysiologicaly adapted to cool climatic conditions in long term basis would be very much sensitive and prefer warm conditions than the usual cool conditions so does their response to a warm colour vs. a cool colour.

Substantiating the hypothesis, it was revealed that the participants significantly perceived a change between the new and previous colour schemes in thermal terms (70.9% - strongly agreed and 29.0% agreed). Regardless of the participants age or gender, the majority consistently (99.9%) perceived red room to be warmer (90.3% strongly perceived and 9.6% perceived). On the other hand 93.5% perceived Blue room to be cooler (64.5% strongly perceived and 29% perceived while 6.4% remained neutral). Also no significant difference between the indoor temperatures of red room vs blue room was identified by the investigation. This finding substantiates the ability of colour red (warm colours) to induce a warm perceived thermal ambience regardless of the actual cold thermal condition. This is a positive association which can be used to create habitable interiors in cold climatic conditions contributing to a thermally comfortable better living environment. Supported by the psychologically induced warm thermal perception, introducing warm colours to a cool climatic situation will make people more active and energetic to counteract the cool pacifying ambience. This in turn will allow them to reduce the heating cost to some extent in the interiors where a heating system is used. On the other hand the study reveals that integrating cool colours in the interiors of a cold climatic condition works negatively as the participants perceive the interior as even cooler than the actual condition making the situation even worse. This will unnecessarily increase the heating cost. It is also suggestive that cool colours can be similarly integrated to manipulate thermal perception in other tropical conditions namely humid, hot, dry...ect.

In conclusion, this study identifies colour as a most potential tool to manipulate the perceived thermal ambience in interiors of cold climatic regions. Significantly, the study recommends integrating warm colours when designing interiors in cold climatic regions to create a thermally comfortable environment while discouraging the use of cool colours. Further it is recommended to develop the research design with reference to interiors where a heating system is involved to test the possibility of energy conservation as a future direction. It is also suggested to test the reverse principle of integrating cool colours to create thermally comfortable interiors in hot humid/dry climatic conditions eventually contributing to saving of cooling costs.

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Selection of Sustainable Composite Partition Material for Sri Lankan context

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Abstract

Building materials are deemed to play a vital role in increasing buildings sustainability while contributing to the economic prosperity. Usage of large quantity of non-renewable resources in the building materials has a major impact on the environment, depriving future generations of its usage. These building materials are used to construct different types of building element. Thus, it is believed that the appropriate selection of building materials for different purposes is one of several factors that contribute to sustainability within the built environment. However, traditionally the selection of such materials depends on consensus-based understanding of environmental issues in designing and construction of facilities. On this note, this study investigates the most suitable composite material that can be used for partition wall construction in Sri Lanka with respect to sustainable parameters. The research is quantitative in nature where a preliminary market survey and a subsequent questionnaire survey were conducted to identify the available materials used in partition wall and evaluate the materials' performance, in terms of embodied energy, toxicity, locally produced material, price, maintainability, aesthetics, resistance and durability respectively. The questionnaire survey was administered to 35 professionals (Architects, Engineers, Quantity Surveyors and Facility Managers) practicing in the construction industry. In order to compare the materials pair wise, an Analytic Hierarchy Process (AHP) based on was employed.

Research findings show that Medium Density Fibre (MDF) board, Gypsum Board (GB) and paddy straw composite board (DURA) are alternatives of composite partitioning materials. In terms of embodied energy (EE), Cost (C), toxicity (T), natural and local available materials (N&L) and maintainability (M) with receiving a relative weight (RW) of 0.471, 0.487, 0.420, 0.398, 0.339 Dura board is preferred over the other materials. However, in terms of aesthetic (A) and resistance (R) criteria with obtaining a RW of 0.414, 0.421 GPD board serves better than other materials. MDF board is at the top in terms of durability with a RW of 0.351. When the overall performance is focused, DURA offers the best value while MDF and GPD board occupy the next places respectively. This study, therefore identifies the most suitable composite alternatives to assist professionals in the selection of most suitable materials for partition walls in Sri Lanka.

Keywords: Partitioning, composite materials, sustainability, construction, Sri Lanka.

1.0 Introduction

Within the past couple of decades, the world has changed with an ever-increasing recognition that the mankind can no longer continue to use natural resources without facing the environmental consequences (Kibert, 2005). This has led to the enhanced concern of the protection of environment in which construction activities take place where sustainable construction has been hailed as a way forward to eradicate the adverse impact on the environment (Asad & Khalfan, 2007). Mora (2007) states that in the perspective of construction, buildings have a profound impact on the environment and even a small change in their sustainability can create a major reduction in the current ecological footprint of the whole society.

Further, Haggag and Elmasry (2011) highlighted that the materials used in building constructions are one of the key areas of architecture to achieve sustainability in the built environment. These materials used for constructing building elements and obtained from the local resources with the help of renewable materials like recycled materials, coral stone, agro waste, etc. If these materials used locally then it may add value to the development of the economy and lead to sustainability while enabling the citizens to have economically benefited. The growing interest in sustainable buildings and the great demand for its profitability in the long run such as improved quality, enhanced durability, enhanced occupational health and safety, material conservation, less construction site waste and less environmental emissions (Chen, Okudan and Riley, 2010) etc has led the researcher to identify alternative sustainable building materials to build building elements.

However, non-structural elements such as partition walls of a buildings are not a part of the main load-resisting system. Therefore, these are often neglected from the structural design point of view and given less important on sustainable parameters (Manike and Sooriyaarachchi, 2008). Further to overcome such this paper begins with a literature review where it identifies the composite materials and sustainable selection criteria. Then, the paper summarizes the findings using AHP tool and identifies the most suitable composite material for partitioning.

2.0 Literature Review

The building material industry consumes more of the earth's natural resources than any human activity. It consumes 40% of raw materials and energy produced on the planet and creates tens of millions of tonnes of greenhouse gasses, air and water pollution and other waste (Erp and Rogers, 2008). Further, Sri Lanka has committed itself to the control of substances that deplete the ozone layer according to the Montreal Protocol (1985) and the emissions of green house gases according to the Kyoto Protocol (1997). In this context, assessment of environmental burdens associated with different construction materials used for buildings is necessary in order for decision makers to select environmentally benign materials (Abeysundara, Babel, and Gheewala, 2009).

In building construction building elements can be categorized as structural and non-structural (Murty, Goswami, Vijayanarayanan, Kumar, & Mehta, 2013). Structural elements bear the dead and live loads while non structural elements do not bear the main loads though they are attached to the building (Murty et al., 2013). Munir (2012) mentions that the columns, beams, foundations and slabs are fallen under the structural elements while cladding, ceiling and partition walls are under the non-structural elements. Therefore this study focuses on the partition wall which includes in non-structural element.

2.1 Composite materials used for partitioning

Sanjay and Mazumdar (2002) define composite as “a macroscopic combination of two or more distinct material having a recognizable interface between them” a(refer figure 1). The composite material has more useful applications when compare to that of constituent materials because composite material consists of two or more basic materials combined in one resulting material (Kanakaji, 2009). The features of such are modulus, bending stiffness, chemical resistance and high specific strength etc. Due to these available advantages this study focus on composite material rather than the constituent material.

Moreover in the arrangement of boards there are a number of different sub-products such as plywood, gypsum board, paddy straw composite board, cement bound composite board and medium-density fibreboard (MDF) (Binggeli, 2008). Although these products are considered as a type of composite board, the sustainability of each differs from one to another on how they are made, where and what they are used for, and how much they cost etc (Binggeli, 2008).

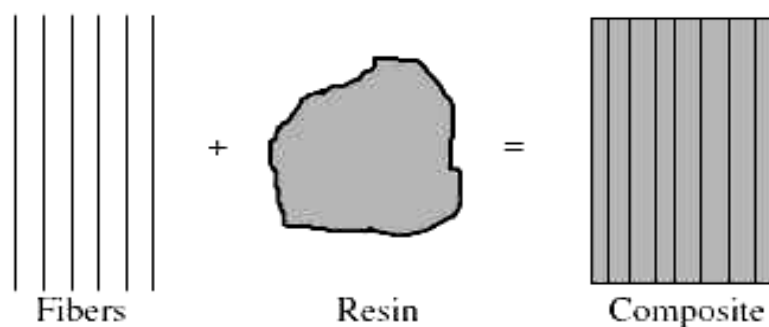


Figure 1: Formation of a composite material using fibres and resin

a. Ply wood

Plywood is manufactured from thin wood veneers, glued together into boards, generally using formaldehyde or occasionally, isocyanine resins. The veneers are produced by soaking logs to soften the fibres, then peeling the veneer off using a rotary cutter or by slicing (Joffe et al., 2003). The plywood ‘core’ may consist of particle board, hardboard or other materials, rather than a veneer (Oslen, 2001). Installation works of plywood partitions are more complicated and time-consuming. The procedures include cutting the wooden studs and plywood boards into specific sizes, fixing the studs and tracks, as well as applying lime and other top finishes. These lead to both higher labour cost and time cost.

Besides, using wood as the major partitioning material is not desirable in view of environmental protection and fire hazard (Chow and Leung, 2011).

b. Medium Density Fibre (MDF) Board

A renewable resource that has been primarily made from wood is known as MDF. MDF is an engineered wood product made by breaking hardwood or softwood residuals into wood fibres, often in a defibrator, combining it with wax and a resin binder, and forming panels by applying high temperature and pressure (McKeever, 2012). MDF is generally denser than plywood. It is made up of separated fibres, but can be used as a building material similar in application to plywood (Rivela, 2007). It is stronger and much denser.

c. Cement-bonded board

Cement-bonded board is an engineered particle composite product prepared from wood or other ligno-cellulosic raw materials bonded with inorganic binders such as cement, chemical additives and water and pressed under regulated pressure. Usually, cement-bonded wood are produced from strands, particles or fibres wood mixed collected with cement and manufactured into panels, bricks, tiles and other products used in the construction industry (Joffe, Andersons & Wallstroma, 2003). This material would reduce or completely eliminate wastages, reduce labour to be engaged and reduce cost as well as the time for construction. According to Adedeji (2011) this material offers several advantages such as design flexibility, light-weight and environment friendliness.

d. Gypsum Particle Board (GPB)

GPB consists mainly of natural gypsum with residual or recycled wood particles. In the manufacturing process for GPB, gypsum is added to water citric acid, pressed into stable and odorless panels, dried, and cut to the customary sizes (Lee et al., 2011). This has superior properties, such as a lack of formaldehyde emission, fire-resistance and sound insulation compared to wood-based panels (Feng et al., 2007) such as particle board (PB), medium density fiber board (MDF), plywood, hardboards and wood flooring (Akgül and Çamlıbel, 2008). Moreover, the wood particles are not dried, and GPB is pressed under cold conditions, which reduces the thermal energy consumption.

e. Paddy Straw Composite (DURA) board

Dura board is a solid building panel manufactured from densely compressed straw using high pressure and heat in the manufacturing process (Dura building systems (Pvt) Ltd., 2013). Jayakody, Kondadeniya, and Jayasinghe (2010) states that straw obtained from paddy cultivation can be a good candidate for manufacturing of straw bonded solid panels in Sri Lanka. Straw bonded solid panels are manufactured by Dura building systems, a subsidiary of the International Construction Consortium, is known as “Dura” panels. They are manufactured to a width of 1.2 m. The length can be 2.4 m, 2.7 m, 3.0 m or 3.3 m. The thickness of the panel is 58 mm. The general applications have been internal partitions and semi – permanent detachable buildings such as site offices, store rooms, etc. Due to densely packed straw, the fire resistance of Dura is high (Jayakody, 2010).

2.2 Selection of Sustainable Materials

Careful selection of sustainable building materials has been identified as the easiest way for designers to begin incorporating sustainable principles in building projects (Godfaurd, Croome and Jeronimidis, 2005). According to Nassar et al. (2003) the sustainability of a building project lies in the selection of building materials. Further, it is emphasised that the life cycle of a building design depends on the choice of appropriate material (Treloar, et al (2001). However, in designing the designer has an objective to make it as cheap as possible, or as light, or as safe or some combination of these (Sirisalee, et al., 2004). Therefore, the selection of building materials is regarded as a multi-criteria decision problem (Akadiri, Olomolaiye and Chinyio, 2013).

On this note, Abeyundara, et al. (2006) has highlighted that a greater environmental burden is placed on concerned parties towards sustainable development by the means of proper selection of building materials. Abeyundara et al. (2006) states that the environmental, economic and social impacts need to be considered for proper selection of material. Chen (2010) further provides seven dimensions for selection of building material under three categories namely, economic, social, and environmental factor. The following sections explain the parameters considered under each of these factors briefly.

1. Economic Factor

a. Cost

The construction clients are very much concern about the buildings' long-term cost effective performance (Bartlett and Howard, 2000). These include the total cost of an item through its life time, including initial cost, maintenance costs, energy costs, cleaning costs, overhead management cost, utilization costs, less any residual value at the end (Emmanuel, 2002). Thus it is said that the Life Cycle Cost (LCC) of the building materials needs to be considered rather than focusing only on the initial cost (Emmanuel, 2002).

b. Durability

Increasing the durability of the materials could enhance the sustainability of a building (Malhotra, 2002). On the same opinion, Treloar (2001) states that, greater the durability of the material is lower the need of time and resources. These resources include such as 38.9% of primary energy use, 38% of all carbon dioxide emissions, and 30% of waste output which is used for building construction in US (U.S. Green Building Council, 2009). Hence, the materials with high durability requires less replacement and produces less amount of landfill waste over the building's lifetime.

c. Resistance

According to Bartlett and Howard (2000), a building's life-cycle cost could be analysed depending on the resistance of materials. Therefore, when it comes to the resistance issues, long lasting materials have to be selected though sometimes it may be turned down as expensive.

d. Maintainability

According to Malhotra (2002), maintenance of a building consumes an important portion of the operational budget. The maintenance expenses include cleaning/polishing materials, equipment, labour costing, and replacements. Zhou, Ang, and Zhou (2010) suggest that the frequent cleaning of the materials may damage the outlook or the exposure of the building occupants as the chemical used for cleaning may damage the material shining or may omit the surfaces. This is mainly because of systems that have to be cleaned only with petroleum-related solvents.

2. Environmental Factor

a. Embodied Energy

“Embodied energy is the amount of energy consumed in manufacturing a unit quantity of a material, and it is usually expressed in KJ/Kg (Sturges, 2000). The embodied energy of building materials will vary from one country to another, depending on the sources of energy used for manufacturing (Emmanuel, 2002). In Sri Lanka there is a wide range of energy sources used in the manufacture of building materials such includes electricity for cement production, fossil fuel for brick production etc. However, aluminium contain a high value of embodied energy while aggregate has a very less value therefore, embodied energy value need to take into account when selecting a material.

b. Use of natural and local materials

Godfaurd et al. (2005) suggest that natural materials are surely lower in toxicity and embodied energy than man-made materials. This kind of natural materials are certainly does not damage the environment or less damage. Josph and Tretsiakova (2010) further, highlighted that the use of natural building materials will definitely help in the reduction of pollution (air, noise, and smoke), travel distances for transport of materials and lower the burdens of environmental aspects etc.

3. Social Factor

a. Aesthetics

Aesthetics of the building is an important thing to bear in mind because it is an asset which creates an image for a company (Bingelli, 2008). Every company would like to promote its construction through the architectural design with a corporate image Therefore, emphasizing the need of aesthetical requirement in the building is said to be one of the few important aspects of sustainability.

b. Use of non-Toxic or less-Toxic materials

The building industry is concerned about the health and community such as workers' health and safety, health of occupants, labour availability, traffic congestion, and community disturbance. Thus, it is important that less hazardous measure with minimal negative impact should be considered always with the use of no or less-toxic materials because it may cause danger to the workers, potential occupants, and surroundings.

The Table 1 represents the composite materials identified for partitioning and its sustainable selection criteria.

Table 1: Composite material and sustainable selection criteria

Composite materials	Sustainable selection criteria
Ply wood	Economic Factor
Medium Density Fibre (MDF)	<ul style="list-style-type: none"> • Cost
Cement-bonded board	<ul style="list-style-type: none"> • Durability
Gypsum Particle Board (GPB)	<ul style="list-style-type: none"> • Resistance
Paddy Straw Composite (DURA) board	<ul style="list-style-type: none"> • Maintainability
	Environmental Factor
	<ul style="list-style-type: none"> • Embodied Energy • Use of natural and local materials
	Social Factor
	<ul style="list-style-type: none"> • Aesthetics • Use of non-Toxic or less-Toxic materials

3.0 Methodology

A comprehensive literature review was carried out initially identifying the composite materials used for partitioning and the criteria to be considered in selection of sustainable materials. As shown in table 1, 5 composite materials and 8 sustainable parameters were identified under 3 criteria namely economic, environmental and social factors. In order to find out materials used in the Sri Lankan context a market survey was conducted.

Further, a questionnaire survey was administered to 35 building professionals which include architects, engineers, quantity surveyors and facility managers to evaluate the performance of the three building materials identified through market survey. 30 participants out of 35 have responded to the survey. The table 2 provides the details of participants' profession and experience.

Table 2: Profile of the research participants

Profession	No.	%	Experience	No.	%
Architects	14	47	0-5 years	8	27
Engineers	4	13	5-10 years	7	23
Facility Managers	6	20	10-15 years	4	13
Quantity Surveyors	6	20	15-20 years	7	23
Total	30	100	20+ years	4	13
			Total	30	100

Pair wise comparison technique was used in assessment of selected sustainable criteria. It enables participants to compare and judge each variable with other. This pair wise comparison technique is based on the Analytic Hierarchy Process (AHP) which is a popular method in solving Multi criteria Analysis (MA) problems (Saaty, 1995; Deng, 1999). AHP therefore consists of mainly five steps Step 1 involves development of hierarchy for all levels while step 2, deploys a pair wise comparison. The step 3 employs normalisation and this is followed by undertaking the consistency

test as step 4. Finally the step 5 involves estimating relative weights. In addition to determining the relative weights, the AHP provides a measure of consistency called consistency index which provides the pertinent information in terms of how consistent the pair wise comparisons are (Mendoza and Prabhu, 1999).

4.0 Data analysis and findings

As explained above the first step of AHP involves developing a hierarchy structure for the assessment problem. In order to carry out this, the problem needs to be identified which is "selection of suitable composite material for partitioning" to structure the hierarchy. Therefore to solve the problem a 3 level hierarchy is determined as observed from Figure 1. The first level is the overall goal (problem) of "selection of suitable composite material for partitioning". The second level consists of 8 criteria: cost (C), durability (D), resistance (R), maintainability (M), embodied energy (EE), Use of natural and local materials (N&L), aesthetics (A), and use of non-Toxic or less-Toxic materials (T) which contribute to attain the goal. Finally, the third level is the decision alternatives of different composite materials such as MDF, GPB and Dura Board that the participants want to compare.

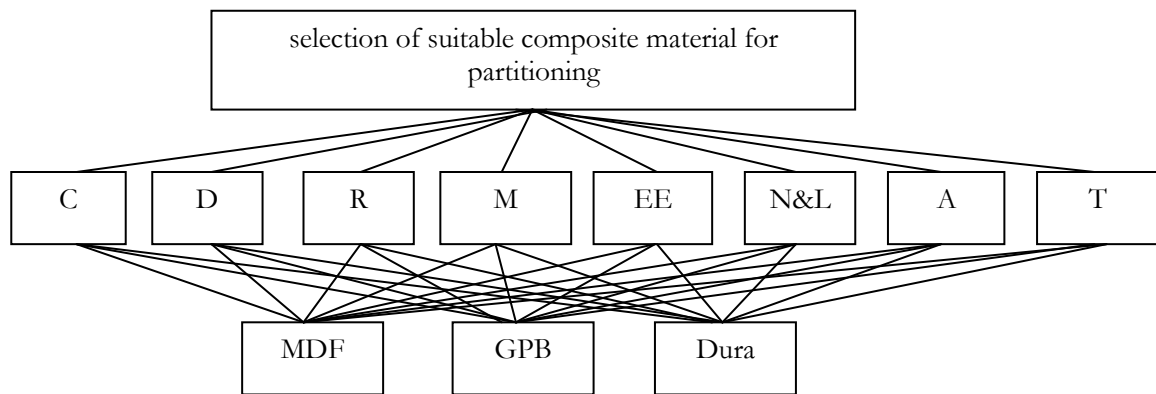


Figure 4: Decomposition of the problem into hierarchy

The second step employs pair wise comparisons among decision elements and form comparison matrices. AHP pair wise comparison procedure represents the relative importance to the decision maker (Ofori, *et al.* 2002). This comparison will enhance a numerical representation in respect to the relative importance between two sustainable criterion in level 2. The numerical quantifications of relative importance were done by using 1 to 9 scales as presented in Table 3. The question to ask when comparing two criteria are as following kind, of the two criteria being compared which is considered more important in selection of sustainable material for partitioning example, if the toxicity (T) criteria is judged to be strong importance than cost (C) in supporting sustainability then a score of 5 is given.

Table 3: Nine point intensity of importance scale and its description (Adapted from Saaty, 2008)

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activates contribute equality to the objective
3	Moderate importance	Experience and judgement slightly favour one activity over another
5	Strong importance	Experience and judgement strongly favour one activity over another
7	Very strong and demonstrated importance	An activity is favoured very strongly over another, its dominance demonstrated in practise
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation.

The pair wise comparisons of the criteria given by the respondents in selection of sustainable material is given in table 4. This compares each element in the corresponding level and calibrate them on the numerical scale. This requires $n(n - 1)/2$ comparisons, where "n" is the number of elements with the considerations that diagonal elements are equal or 1 and the other elements will simply be the reciprocals of the earlier comparisons (Vaidya and Kumara, 2006). These results were further taken ahead to satisfy the fourth step of the AHP analysis which is to normalise the pair wise

comparison matrixes. The normalization can be done by dividing each entry by the sum of the entries in its column (Ehrhardt and Tullar, 2008) and then get the sum of each row. Subsequently, dividing each sum by the total of all the sums (Darin, 2008) to derive the Performance Score or Relative Weight (RW) enables to compare each sustainable criteria in the matrix. The table 4 represents the normalized values for sustainable criteria.

Table 4: Normalized comparison for sustainable criteria

Criteria	EE	C	T	N&L	A	Re	D	M	SUM	RW
EE	0.181	0.402	0.308	0.201	0.171	0.091	0.096	0.073	1.524	0.190
C	0.046	0.102	0.326	0.128	0.128	0.074	0.079	0.095	0.979	0.122
T	0.093	0.049	0.158	0.393	0.248	0.369	0.314	0.240	1.864	0.233
N&L	0.088	0.078	0.039	0.098	0.163	0.197	0.193	0.132	0.990	0.124
A	0.063	0.047	0.038	0.036	0.059	0.063	0.049	0.121	0.476	0.059
R	0.191	0.133	0.041	0.048	0.090	0.096	0.130	0.150	0.879	0.110
D	0.165	0.113	0.044	0.044	0.107	0.065	0.088	0.119	0.744	0.093
M	0.172	0.075	0.046	0.052	0.034	0.045	0.051	0.070	0.545	0.068
	Sum of relative weights									1.000

According to Ehrhardt and Tullar (2008), a perspective with a higher RW is preferred over one with a lower RW. Thus, toxicity received the highest performance score of 0.233 among the eight sustainable criterions (refer table 5). Obtaining the final relative weights (RW) the sustainable criterions can be ranked as shown on Table 5.

Table 5: Ranking of sustainable criterions

Criteria	Relative Weights (RW)	Rank
Toxicity (T)	0.233	1
Embodied Energy (EE)	0.191	2
Natural or locally produced material (N&L)	0.124	3
Cost (C)	0.122	4
Resistance (R)	0.110	5
Durability (D)	0.093	6
Maintainability (M)	0.068	7
Aesthetics (A)	0.060	8

Similarly pair wise comparison was carried out among all composite materials with respect to all sustainable criterions which is presented in table 6 to 13.

Table 6: Comparison of materials respect to Embodied Energy

EE	MDF	GPD	DURA	RW
0.191				
MDF	0.281	0.221	0.231	0.244
GPD	0.298	0.312	0.243	0.284
DURA	0.504	0.484	0.426	0.471

Table 7: Comparison of materials respect to Aesthetic

A 0.06	MDF	GPD	DURA	RW
MDF	0.233	0.254	0.263	0.250
GPD	0.433	0.399	0.411	0.414
DURA	0.350	0.346	0.311	0.336

Table 8: Comparison of materials respect to Cost

C	MDF	GPD	DURA	RW
0.122				
MDF	0.279	0.255	0.222	0.252
GPD	0.243	0.295	0.244	0.261
DURA	0.467	0.482	0.513	0.487

Table 9: Comparison of materials respect to Resistance

R 0.11	MDF	GPD	DURA	RW
MDF	0.273	0.248	0.247	0.256
GPD	0.411	0.431	0.420	0.421
DURA	0.304	0.314	0.352	0.323

Table 10: Comparison of materials respect to Toxily

T	MDF	GPD	DURA	RW
0.233				
MDF	0.313	0.355	0.315	0.328
GPD	0.217	0.256	0.285	0.253
DURA	0.426	0.410	0.423	0.420

Table 11: Comparison of materials respect to Maintainability

M	MDF	GPD	DURA	RW
0.068				
MDF	0.319	0.325	0.341	0.328
GPD	0.341	0.304	0.352	0.332
DURA	0.330	0.346	0.342	0.339

Table 12: Comparison of materials respect to Natural & Local material

N&L	MDF	GPD	DURA	RW
0.124				
MDF	0.379	0.355	0.385	0.373
GPD	0.241	0.227	0.218	0.229
DURA	0.402	0.399	0.394	0.398

Table 13: Comparison of materials respect to Durability

D	MDF	GPD	DURA	RW
0.093				
MDF	0.353	0.325	0.375	0.351
GPD	0.321	0.355	0.311	0.329
DURA	0.333	0.315	0.312	0.320

Table 6 to 13 depicts the values obtained for each alternative materials for partitioning with respect to each sustainable materials. The best materials with respective to each criterions varied example; Dura is best comparatively with respect to embodied energy (EE), Cost (C), toxicity (T), natural and local available materials (N&L) and maintainability (M) with receiving a relative weight (RW) of 0.471, 0.487, 0.420, 0.398 and 0.339. GPD is comparatively best compared with the aesthetic (A) and resistance (R) criterions with receiving a RW of 0.414 and 0.421. Moreover, MDF is considered to be best with regard to durability (D) by achieving a RW of 0.351.

However to compute the contribution of each alternative to the overall goal "selection of sustainable composite material for partitioning" the overall weight is obtained by summing up all weights. Obtained final weights and ranking of alternatives to overcome the problem is shown in table 14.

Table 14:

	EE	C	T	N&L	A	R	M	D	Overall weight	Rank
	0.191	.122	0.233	0.124	0.06	0.11	0.068	0.093		
MDF	0.244	0.252	0.25	0.256	0.328	0.373	0.351	0.328	0.282424	3
GPD	0.284	0.261	0.414	0.421	0.253	0.229	0.329	0.332	0.32837	2
DURA	0.471	0.487	0.336	0.323	0.42	0.398	0.32	0.339	0.389982	1

The computation of overall weight for alternative material for MDF is as follows;

$$\text{Overall weight MDF} = (0.244 \times 0.191) + (0.252 \times 0.122) + (0.25 \times 0.233) + (0.256 \times 0.124) + (0.328 \times 0.06) + (0.373 \times 0.11) + (0.351 \times 0.068) + (0.328 \times 0.093) = 0.282424$$

Similarly, 0.5292 and 0.6136 are for GPD and Dura respectively.

This was followed by a consistency measure as the fifth step to control the results of AHP. This is expressed through the following equation 1, where the measure of inconsistency is called consistency index (CI). The consistency ratio (CR) which is used to estimate directly the consistency of pair wise comparisons. The CR is computed by dividing the CI by a value obtained from a table of Random consistency Index (RI) which is shown in equation 2.

$$CI = \frac{(\lambda_{max} - n)}{(n - 1)} \quad 1$$

(Adapted from; Saaty, 1980)

Where, " λ_{max} " is the maximum eigenvalue and "n" is the number of factors in the judgment matrix.

$$CR = \frac{CI}{RI} \quad 2$$

(Adapted from; Saaty, 1980)

In this study with respect to the pair-wise comparison of 8 sustainable criteria $\lambda_{max}=8.651$, $CI=0.093$ were derived. This is accompanied to calculate the consistency ratio (CR), which is used to estimate the consistency of pair wise comparison which resulted in CR of 0.066. According to Saaty (1980) if the CR is less than 0.10 the comparison is accepted. However the CR value for this is $0.066 < 0.1$ which means all the respondents results are consistent.

5. Conclusion

This study was based upon a model introduced by (Saaty, 1980) which determined the relative weights for different partition material alternatives. This examines the 8 sustainable criteria namely toxicity (T), cost (C), aesthetics (A), durability (D), embodied energy (EE), locally produced material (N&L), resistance (R) and maintainability (M) and its benefits in selection of suitable composite material. The AHP methodology could help assess relevant criteria critically and logically while assisting to make sensible decisions.

However, This study was carried out based on the perceptions of professionals involved in the construction industry among architects, engineers, quantity surveyors and facility managers through pair wise comparison. The findings shows that Dura is the best in terms of embodied energy (EE), Cost (C), toxicity (T), natural and local available materials (N&L) and maintainability (M) with receiving a relative weight (RW) of 0.471, 0.487, 0.420, 0.398 and 0.339. GPD is comparatively best compared with the aesthetic (A) and resistance (R) criterions with RW of 0.414 and 0.421. Moreover, MDF is considered to be best with regard to durability (D) by achieving a RW of 0.351. However, by combining the overall weights it is observed that the order of preference is; Dura, GPD and MDF. At the end it is concluded that Dura alternative is the solution for the problem achieve performance excellence in selection of suitable composite material for partitioning.

Finally, the aim of this study was accomplished by identifying the most sustainable composite partitioning material for Sri Lankan context. Moreover the suggested findings with regard to partitioning is in essence of strategic outline which would help as being a tracking tool that can be used by the construction practitioners.

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A Study of Payment Issues to Constructors in the Sri Lankan Construction Industry

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Abstract

Payment issues to main contractors and the subcontractors have been a major concern in the construction industry. This research therefore, investigates the payment issues to constructors in the Sri Lankan construction industry. A survey approach using semi structured interviews was adopted.

The research found delayed payments are mostly experienced than incomplete or non-payments. Government funded projects are highly exposed to delayed payments. Final payments are always delayed compared to retention and interim payments. Subcontractors are critically affected than main contractors. The findings indicated that the top three causes of delayed payments are paymaster's poor financial management, delays in certification by consultants and improper bills from the contractors.

The research therefore, recommended that parties need to procure appropriate security measures in the form of having a payment bond from the upper tier, separate form of contract to subcontractors and construction contract act. This would ensure that contractors get paid on time and thereby contribute to the success of the project.

Keywords- *Sri Lanka, construction industry, payment issues, main contractor, subcontractor*

1.0 Introduction

The client and the contractor are legally bound by the terms and conditions in a construction contract where payment is made on time is the liability of the client (Balamuralithara, Chong, & Chong, 2011). From the contractor's perspective, payment is the most important aspect of any construction project. However, from the owner's perspective, payment is the ultimate leverage to compel contractor's performance (Hussin & Omran, 2009).

Payments to contractors in construction industry are categorized as advance payment, interim payment, final payment and retention payment (Kaka & Motawa, 2008). The advance payment could help the contractor to relieve the financing problem during commencement of construction work (Hussin & Omran, 2009). According to Jayalath (2013), the purpose of interim payment is to ensure that the contractor is regularly paid throughout the progress of works, which leads to maintain cash-flow, thus minimizing any deficit which may otherwise affect the smooth running of the project. Koksai (2009) stated that the retention money is retained against the risk of non-compliance of work on time of the contractor. Liebing (2007) suggested that final payment is the last payment made by the client to contractor of the entire unpaid balance of the contract sum. Hence, payment plays a vital role in a construction contract. When the timing and quantum of payment affected, payment issues could arise. Payment issues can be either delays, incomplete or non-payments (Ramachandra & Rotimi, 2011).

Delayed and non-payment risk is primarily due to counterpart's 'cannot', 'would not' pay attitude or both. It is evidenced in large number of construction projects where the owners simply refuse to pay the contractors once the project is completed (Meng, 2002). Further, Meng (2002) stated that for some projects sufficient funding sources are not secured before project start and the contractors often agree to be paid after the work is fully or partly completed. Khosrowshahi (2000) stated that the chain payment culture within the construction industry where payment flows from the upper to lower levels makes the payment to lower levels depend on the upper levels. Therefore, when there is a payment issue at upper level it affects the lower level too. For example, if the client delays the main contractor's payment, main contractor delays to pay the subcontractor, then sub-contractor also fails to pay his supplier. Thus, Payment issues may cause series of effects in the payment chain.

Hence, payment issue is a serious problem in the construction industry of many countries and this could be attributed to the nature, consequences and risk associated with the industry (Ramachandra & Rotimi, 2012). Majority of contractors reported that delayed payment situation in government funded projects was commonly experienced whilst more of them affirmed the same situation in private funded projects (Hasmori, Ismail, & Said, 2012).

According to National Construction Association of Sri Lanka (2009), payment issues to contractors become serious concerns in the Sri Lankan construction industry. Jayalath (2013) is of the opinion that continuous progress payments could enable the contractors to maintain the cash flow and thereby ensure the success of the project. Despite the significant of payment issues received within the Sri Lankan construction industry, there seemed to be lack of research address to this area. Therefore, the research intended to investigate the nature and the causes of payment issues in the Sri Lankan construction industry.

2.0 Brief literature review

2.1 Payment in construction industry

Payment is considered as lifeblood of the construction industry because constructions often involve very large capital outlays and take a considerable time to complete (Ameer, 2005). Construction industry and payments have a strong relationship in a construction contract (Hasmori et al., 2012). In a construction contract client and the contractor are legally bound by terms and conditions where payment considered as reward for the work performed (Balamuralithara, Chong, & Chong, 2011).

Payments are a major concern as money is needed to pay for materials, labour, plant, subcontractors' account rendered, preliminaries and general overheads expended during the progress of the work (Frics & Smith, 2012). Kaka, Morledge, and Odeyinka (2003) pointed out that many construction companies have negative net cash flows and become bankrupt due to lack of liquidity for supporting their day-to-day activities which is caused by improper payment practices. Therefore, the practice of efficient and timely payment in construction projects is a major factor that can contribute to a project's success (Danuri, Munaaim, & Rahman 2012).

Construction payment issues have attracted wide concerns in the industry for many years in both developing and developed countries (Chen, Hou, & Liu, 2011). Payment has been an issue of major concern in the construction industry and majority of contractors reported that they have gone through such issues in government funded projects whilst more of them affirmed the same situation in private funded projects (Hasmori et al., 2012). Rahman and Ye (2011) stated that payment issue is endemic in construction and needs to be explicitly recognized as this problem recurs from project after project.

Hussin and Omran (2009) described that common issue related to advance payment is delay in realizing such payment. The Aqua group (1996) expressed that when the client delays the advance payment then the contractor tends to start the construction in a slow manner because such a situation the contractor has to use his own money or the money borrowed from financial intermediaries. With regards to the interim payment, the contractor will only receive the payment after completed the progress of works. Problems in granting the relevant interim payment certificate in line with stipulation of the contract will create issues in interim payment (Singh, 2003).

The rapid increase of the delays and losses in the final payments nowadays have gone to the point that it tends to decrease the good image of the construction industry in many countries (Ismail, Yusof, & Zakaria, 2012). Issues in closing of final accounts occur during rationalization of rates as well as due to the ignorance of contract administrator staffs in rationalizing the rates on time (Sambasivan & Soon, 2007). Another factor contributed by contractors to the issues in the final accounts closing is the contractors fail to agree with the variation of work (Battaineh & Odeh, 2002). RICS (2012) noted that if the retention is not set aside in a separate marked account, this is likely to lead to delay or default in such payment. Ramachandra and Rotimi (2012) found that retention payment is very often delayed while final and interim payments are delayed less than often in the New Zealand construction industry.

Carmichael and Tran (2012) mentioned that subcontractor payments typically come through the contractor, their timing and quantum can be affected by the upstream payment practices of the owner to the contractor, as well as the payment practices of the contractor. Thus, the extent of payment issues could be differs in terms of types of issues, clients, payments and industry groups.

2.2 Causes of Payment Issues

In order to give a better understanding about the payment issues, it is appropriate to discuss the causes of payment issues in the global construction industry. Based on the literature review the following factors have been identified as some of the potential causes of payment issues in the construction industry.

2.2.1 Poor financial management of paymasters

Qualified contractors are often unwilling to bid on projects for employers whose financial capacity and credit rating are not widely known (The Associated General Contractors of America, 2003). Thus, it is extremely important for the employer to manage his financial aspect in a good manner as it is a major factor in determining the project's success. It is anticipated that paymasters' poor financial management could cause contractors insufficient operating funds when the latter are obliged to pay the payees (Danuri et al., 2012). Further, it is emphasized that the late payment or even non-payment therefore could arise. Ayudhya (2012) identified that the top most important factor attributing to the payment issues faced by main contractor in residential building contract in Thailand, was owners' financial problems.

2.2.2 Delay in certification

According to Rahman and Ye (2010), delay in certification by parties involved, may also cause of payment issues. The parties involved may delay in approving the application for payment claim due to certain reasons which may arise because of his own or other parties' involvement. According to Ayudhya (2012), there were often complains from main contractors to consultants and owners that the evaluation of both quality and quantity of completed work was caused in payment issues. This was due to difference on aspect of quality and measurement of quantity of completed works. Presently, the main contractor's side was responsible for quality control whereas the acceptance testing responsibility falls into the consultant's hand. Danuri et al. (2012) noted that consultants have an attitude of delaying the approvals for claims to the contractor. Therefore, it is clear that delay in certification directly affects the timely payment.

2.2.3 Errors in bill

Ismail et al. (2012) stated that the main reason for payment issues is errors in the claims submitted. This includes claims without adequate supporting documents, wrongly calculated claims and those submitted without using the right procedures and when this happens, contractors need to resubmit the claims and repeat the whole process after making necessary corrections. The contractors need to submit the progress billing attached with the approved percentage of completion by the authorized person in charge. Most of the problems occur when contractors miss necessary supporting documents. According to Ayudhya (2012), in order to avoid payment issues, the quantity surveyor has to make sure that documentations are complete and accurate. Further Ayudhya (2012) stated that payment is only made to main contractor when all required documents are verified otherwise it leads to payment delays and losses.

3.0 Research method

Survey approach was adapted to the current study. Survey provides a relatively quick and efficient method of assessing information about the population (Kelley et al., 2003). Such information may be quantitative or qualitative. Survey approach facilitates the researcher to collect data through the main methods of asking questions face-to-face or through telephone, by using questionnaires, interviews or a mixture of two (Kothari, 2004). This research focuses on getting the views of the different disciplinary practitioners who have exposed in payment issues.

In survey approach, selection of sampling technique to draw sample from the total population is significant. Purposive sampling technique was selected for this study as the research required the professional who experienced in payment issues within the construction projects. Choosing the purposive sample is fundamental to the quality of the data collected; thus reliability and competence of the informant must be ensured. Sandelowski (1995) indicated that adequacy of sample size in qualitative research is relative, a matter of judging a sample neither small nor large. Further, Sandelowski (1995) suggested that a sample size of 10 can be judged as adequate for a certain category of participants. Accordingly, ten participants from each group; consultants and main contractors were selected for this study. Therefore, semi structured face-to-face interviews were conducted with twenty research participants.

Thematic analysis is the most common form of analysis in qualitative research (Boyatzis, 1999). It emphasizes pinpointing, examining, and recording patterns themes within data. Themes are patterns across data sets that are important to the description of a phenomenon and are associated to a specific research question (Guest, MacQueen, &

Namely, 2012). The collected views of interviewees were analyzed through thematic analysis using NVivo 7. The research findings are presented in the next section.

4.0 Research Findings

4.1 Participants profile

Prior to collect views for questions the participants were required to indicate their background information which includes designation, years of experience, nature of the work provided by the organization, ICTAD grading of the organization and number of employees. The research participants were selected from major industry groups: consultants and main contractors who have experienced payment issues in Sri Lankan construction industry.

Among the consultants, 50% are directing the organization, dealing with the research issue at managerial levels and remaining 50% are the senior quantity surveyors who are directly dealing with the payment issues. Among the main contractors, 60% are directing the organization and remaining 40% are the top level staffs of contracting organization: chief quantity surveyor, project manager and general manager who are handling the payment issues with the client and contractors. The selected organizations are involving in buildings and infrastructure projects of public and private sectors. The contracting organizations which are having the ICTAD grading C1 to C9 are considered to this research by selecting the participants of at least one from each organization. The selected organizations are providing services to buildings and infrastructure projects. Most of the participants have more than 20 years experience in construction industry.

A summary in Table 4.1 gives a good participants' profile information which suggests that the research findings are reliable.

Table 4.1: Profile of research participants - Consultants and main contractors

Interviewee Code	Designation	Years of experience	Nature of the work provided by the organization	ICTAD grade
Consultants				
C-I01	Director	20	Consultancy services	-
C-I02	Director	20	Cost, project, claim, disputes management	-
C-I03	Director	25	Cost, project, claim, disputes management	-
C-I04	Director	40	Quantity surveying, post contract cost management	-
C-I05	Senior Quantity Surveyor	20	Quantity surveying, post contract cost management	-
C-I06	Director	20	Consultancy services	-
C-I07	Senior Quantity Surveyor	10	Consultancy services	-
C-I08	Senior Quantity Surveyor	15	Consultancy services	-
C-I09	Senior Quantity Surveyor	19	Roads & infrastructure projects	-
C-I10	Senior Quantity Surveyor	19	Consultancy services	-
Main contractors				
MC-I01	Chief Quantity Surveyor	21	Construction of buildings and infrastructure projects	C1
MC-I02	Chief Quantity Surveyor	20	Construction of buildings and infrastructure projects	C1
MC-I03	Project Manager	23	Construction of infrastructure projects	C2
MC-I04	General Manager	42	Construction of infrastructure facilities	C3
MC-I05	Director	20	Construction of infrastructure projects	C4
MC-I06	Director	20	Construction of building projects	C5
MC-I07	Owner	8	Constructions building projects	C6
MC-I08	Owner	9	Construction of building projects	C7
MC-I09	Owner	12	Construction of building, roads and culverts	C8
MC-I10	Owner	10	Construction of roads and culverts	C9

4.2 Nature of payment issues

4.2.1 Types of issues

The empirical data disclose that the Sri Lankan construction industry is experiencing payment issues for many decades. Majority of the respondents (95%) are of the opinion of payment delays occur very often comparing to incomplete and non-payment. An interviewee (C-I04) expressed that incomplete payment occur only when it is reasonably proved by consultant. However, at the end of the project the contract price would be paid to the contractor as per MC-I04 and MC-I01. Further, an interviewee (MC-I03) specified that contractors experience incomplete payment in variation works the matters disputed with variations could be resolved in final payment certificate. Therefore, incomplete payments are not considered in this research. Most of the respondents (90%) confirmed that non-payment is rarely experienced by the contractors in Sri Lankan construction industry. Hence, the research investigates particularly the payment delays. The next sub section discusses the frequency of delayed payments in relation to types of payments.

4.2.2 Types of payments

The extent of the payment delays differs according to the types of payment. The following Figure 4.1 shows the frequency of delays within the types of payments.

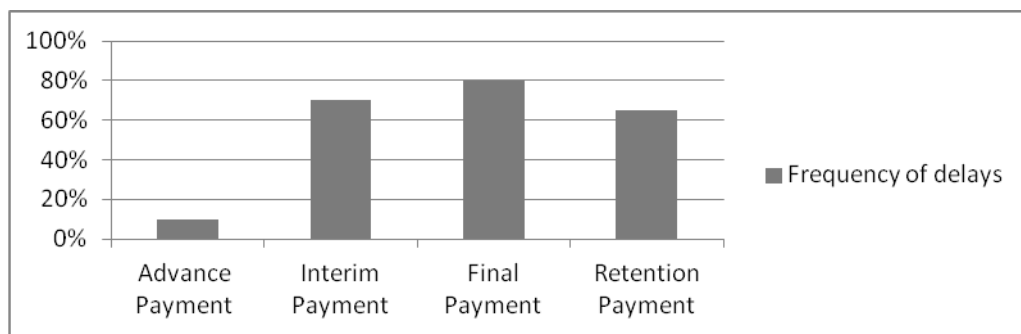


Figure 4.1: Types of payments

According to the above Figure 4.1, 10% of the participants only agreed that advance payments are delayed. An interviewee (C-I01) indicated that delay in advance payment occurs when client's financial arrangements mainly depend on the bank loans. The bank requires contract document to provide loan. However, the advance payment shall be released after the issuance of letter of acceptance. Thus, there are procedural delays with the banks. Majority of the respondents (90%) indicated that advance payments are not delaying because the client needed the early commencement of the project.

Majority of the respondents confirmed that delays in interim payments follows smoothly in the early stages and however it delays in later stages of project. The client reluctant to pay for the poor quality work of the contractor and consultant delays the certification of improper bills. 70% of the consultant participants are with the same opinion of the interim payments paid on time in the initial stages whereas delays occur from the middle stage of the project because of the cash flow difficulties of client. An interviewee (MC-I04) expressed that more trades are occurring during the middle stage of the project. Therefore, the value of interim payment application is considerably high during middle of the project. An interviewee (MC-I02) explained that interim payments are always delaying. MC-I05 agreed with MC-I02. 70% of the main contractors' representatives experienced delays in interim payments when the project moves towards the later stages. MC-I09 and MC-I10 reported they are not aware of interim payment as they are entitled to get two payments probably.

70% of the consultant participants mentioned that there is always delays in final payments as the contractor included all the variations and the disputed quantities which are not sorted out in the previous interim bills. 20% of the consultant participants reported that delays in final payments occur because of client's cash flow difficulties at the end of the project whereas C-I03 expressed that client reluctant to pay when the project finished. An interviewee (C-I09) responded that there is a long procedure to be followed in final payments. 90% of interviewees from main contractor group experienced delay in final payment whereas 60% from them reported final payment are mostly delayed than interim payments. Final payment application contains variation and all the disputed quantities which were not sorted out in pervious bills. Therefore, there is a possibility for delay rather than other types of payments. In contrary, an interviewee (MC-I04) expresses final payments are not delaying mostly like interim payments.

The empirical data reveals that even though there is a provision of getting retention fully at the completion by providing retention bond, the contractor are not utilizing that. 65% of the research participants indicated that retention payments are made on time when there are no defects in the project. C-I04 and C-I10 also in lined with the views of C-I03. An interviewee (C-I07) suggested that client delays the retention payment as because of his financial problems. 30% of the consultant representatives reported that clients are reluctant to pay the retention payment as the project completed. Further, an interviewee (C-I03) confirmed that client tries to get undue advantage by without paying the retention payment. The next section will discuss the payment issues related to types of clients.

4.2.3 Types of clients

Survey findings indicate that there are four types of client: local government, foreign government, corporate and individuals operating within the Sri Lankan construction industry. It appears that public projects are funded fully by local government or foreign government or in a combination of both. Private projects are funded purely by individual or corporate. Currently, the Sri Lankan construction industry is at growing pace with large scale buildings and infrastructure projects according to the above funding arrangements.

90% of the research participants (excluding C-I02 and MC-I06) explained that payment delays mostly exist with the projects fully funded by local government. Majority of respondents (95%) disclosed that government doesn't have money in treasury and there is a long procedure to be followed to make the payment. Therefore, payment delays occur in government projects. An interviewee (C-I01) accounted that the Sri Lankan government's financial discipline has gone down and it is on under drive. Without showing the development of country through construction of buildings and infrastructure projects, government could not survive. Hence, government starts the project without having proper policy planning to develop the country. An interviewee (C-I04) expressed there is a red tape in the procedure, the person signing the documents and forms is arising so many questions some are necessary to clarify and some are irrelevant. An interviewee C-I01 also in lined with the opinion of C-I04. 80% of research participants express that payment delays are very rarely occur in the projects funded by foreign government as the fund is ready before the awarding of the project. Therefore, payment follows smoothly in foreign funded projects.

85% of the interviewees (excluding MC-I06, MC-I07 and MC-I08) agree that private clients are good paymasters comparing to local government. An interviewee (C-I07) indicated that corporate clients are stable in their financial aspects. Corporate client establishes a proper budget initially and source the funding prior to initiate the project whereas individual clients enter into contract by having half of the arrangement of budget. MC-I02 and MC-I06 also in lined with the views of interviewee C-I07. Therefore, individual client tends to delay the payment in later stages of the project and corporate client make the payment on time from the start to end of the project.

According to the empirical findings, foreign government client and corporate clients are considered as good paymasters whereas local government client always delays the payment and individual client delays the payment at the end of the project. The next sub section addresses the payment issues related to types of industry groups.

4.2.4. Types of industry groups

As per the empirical findings, 75% of the research participants (25% consultants and 50% main contractors) revealed that subcontractors are mostly suffered by the payment delays comparing to main contractor. The main contractors are in the upper stream in payment chain, therefore subcontractor's payment goes from main contractor. An interviewee (C-I02) expressed that always there is a back to back arrangement irrespective of "pay when paid" clauses included or not. C-I05 accounted "pay when paid" clauses are called as exculpatory clauses and those are not so legally enforceable. 30% of the interviewees from consultant group responded that there is no proper form of contract for the subcontracting works in the Sri Lankan construction industry and the main contractor establish the subcontracting document fair with biasness. C-I02 responded that subcontractors do their business with few pages contract agreement and sometimes without that even. The subcontractors are absorbing the situation to get the job and survive in the industry.

MC-I03 reported that main contractor's cash flow is so critical and the payment values are considerably high. Further, main contractor has to spend huge amount of money for the construction works, subcontractors, suppliers, staffs, creditors and ect. Therefore, main contractors are affected severely because of delayed payments. MC-I05 also in lined with the views of MC-I03.

Since the evidences revealed that both the main contractor and the subcontractor are suffered by the delayed payments, the subcontractors are in critical plight than the main contractors in Sri Lankan construction industry.

5.0 Causes of delayed payments

The research participants were required to specify the causes of payment delays in construction industry. Figure 5.1 shows the outcomes of collected views on causes of delayed payments using NVivo structured under sub headings: due to clients, consultants, contractors and other factors. In the figure the sources represented the frequency of respondents who are in lined with the particular theme.

Name	Sources
Causes for Delayed Payments	0
Due to clients	0
Paymaster's poor financial management	14
Cost overrun	9
Failure to source the funding prior to initiate the project	8
Local culture or attributes	5
Paymaster's with holding of payment	4
Trustworthiness between parties	2
Client's unawareness on repercussions of payment delays	1
Due to consultants	0
Delay in certification	12
Cost overrun	9
Local culture or attributes	5
Trustworthiness between parties	2
Exploitation	1
Frequent design changes	1
Poor preliminary estimates	1
Due to contractors	0
Improper bills from contractor	10
Cost overrun	9
Poor quality of work	2
Trustworthiness between parties	2
Due to other factors	0
Procedural delays	4
Procurement system	4

Figure 5.1: Causes for payment delays

According to the empirical findings, paymaster's poor financial management is the key factor contributing to delayed payments to contractors. 70% of the research participants agree with the above statement in which half of them are contractors and remaining are consultants. An interviewee (MC-I04) indicated that towards the end of the project the client faces financial hardship leads which to delay payments in construction projects.

The second important cause recognized by 60% of the interview participants is delay in certification of payment application. Majority of the consultants indicate delays in certifying the payment application is unintentional. It is often because of the construction work load and the existing measure and pay system. As per C-I01 and C-I02, practicing measure and pay system particularly for the complex projects tend to incur more time for repeating measurement works, causes delay in certification.

The third important cause identified by 50% of the respondents is improper bills submitted by the contractors. As per C-I02 contractor's own fault causes largely to payment problems. Other than C1 and C2 contractors submit payment application with inaccurate quantities and without all supporting documents even without following the standard method of measurement. In contrary, consultant fails to finalize the bill formats in the early stages and consultant does

not attend to joint measurement. The aforementioned faults of the consultants lead the contractor to submit the improper bill as per MC-I03 and MC-I06.

The fourth significant cause for delayed payments identified by 45% of the research participants is cost overruns. As per C-I06, cost of the project increase the set budget in almost all projects because of the variations and extra works. Set budget is calculated as engineer's estimate plus 10% of estimate. C-I04 reported 10% allocation for variations and price escalation is not enough practically. Nowadays, projects are experiencing up to 40% of estimated cost for variations as per interviewees C-I04 and MC-I04.

The fifth cause for delayed payments identified by 40% of the research participants is failure to source the funding prior to initiate the project. Two of the interviewees (MC-I09 and MC-I10) indicated that most of the time government initiates the projects before the allocation of funds. Individual clients start the process with half of the budget arranged. Therefore, when the project moves there is a possibility of inadequate fund as per interviewees C-I10 & MC-I04. An interviewee (C-I05) specified that client's banking arrangement is not smart enough to honour the payment on time.

Following the explanation of causes for delayed payments, the next section tends to discuss the findings of the survey conducted within the industry practitioners.

6.0 Discussion

6.1 Nature of payment issues

According to the research findings, payment issues are identified as delays, incomplete and non-payments. Among these three types of issues, payment delays are critical in Sri Lankan construction industry. Delayed Payments are more frequent than losses (Ramachandra & Rotimi, 2012). Therefore, this seems the findings of the survey are in lined with the existing literature. Further, the empirical data disclosed that the concept "incomplete payment" is not accepted by the practitioners in the industry as the contract price is paid to the contractor at the end of the project anyway. Therefore, both contractors and consultants have same opinion that losses of payment happen rarely. The participants selected for this study have not experienced non-payment and they have not encountered any non-payments in the industry. Therefore, this research particularly focused on delay payments.

Hasmori et al. (2012) suggested that delayed payment situation in government funded projects was commonly experienced whilst more of them affirmed the same situation in private funded projects. However, the current study indicates that delayed payments are mostly experienced in the projects which are purely funded by local government as the government fails to source the funding prior to commence the project and existing lengthy procedures in government sectors. Generally, the payment issues are very less with the foreign funded projects as the fund is available before award the contract to particular contractor while corporate clients also considered as good paymasters as they have some sort of separate financial department to deal with financial matters. The delayed payments with the individual client vary according to time and each individual. In the early stages, payments made on time and latter stages payment delays occur because individual clients start the projects without sourcing the complete budget before initiate the project.

The extent of the delayed payments differs according to the types of payment. Advance payment is very rarely delayed as the client tends to provide the advance payment on time to commence the project. Retention sums are very often delayed while final and interim payments are delayed less than often (Ramachandra & Rotimi, 2012). However, the findings of current research indicates that final payments are delayed very often compare to interim and retention payment as final statement contains all the disputed items and quantities of previous interim bills, particularly variations. The client faces financial difficulties at the end of the project. Therefore, interim payments during the end of the project are delayed. The paymasters take undue advantages by delaying retention payments as the project has finished already. However, the retention payments are not delayed often.

Carmichael and Tran (2012) stated that the uncertainty in subcontractors' payments is increased because of the payment behaviour of clients and contractors. According to the survey, it was identified that the subcontractors are the mostly affected party in the payment chain comparing to the main contractors. There is no protection for the subcontractor's payment in their contract document. The subcontractors are entering into contract with a few pages subcontract agreement in spite of subcontract document with a set of terms and conditions. Most of the time subcontract agreement contains "pay when paid" clauses. Main contractors have always transferred all the risks to subcontractors. The subcontractors are financially not stable and they are in the bottom of payment chain therefore, subcontractor's status is critical in construction industry. However, the main contractors with lower ICTAD grading are also suffering a lot as their financial instability. To sustain in the construction industry, subcontractors and the small sector contractors are absorbing the situation and remain. Thus, the construction industry operates.

6.2 Causes of delayed payments

According to the views of research participants, the causes of delayed payments are attributed to clients, consultants, contractors and other factors. The top three causes of delayed payments are identified as client's poor financial management, delay in certification of payment application by the consultant and improper payment application from contractor. This seems all three parties are contributing to delayed payments. Further, the research indicates that cost overruns and failure to source the fund prior to initiate the project are some other important causes contributing to delayed payments. Most of the current research findings are in lined with the existing literature. However, there are certain new causes to existing literature have been identified: trustworthiness between parties, failure to source the fund prior to initiate the project, cost overrun, poor preliminary estimate, exploitation, frequent design changes and poor quality of work, procedural delays and procurement system.

Cost overrun is identified as significant cause contributing to delayed payments. Most of the time client's requirements increase when the time moves. Further, there are variations arise with the construction process because of several reasons. Therefore, these will leads to cost overruns. Then, the contract price exceeds the client's budget, the client faces difficulties to source the exceed amount. Thus, there are more delayed payments at the end of the project.

Failure to source the fund prior to initiate the project is recognized as the next important cause of delayed payments. The local government is often practicing in such a way. Government has to show the country's development through the construction of buildings and infrastructure projects. Therefore, government start the projects before arrange the adequate fund. Even, individual clients also start the project with the available fund not with the arrangement of complete fund. Therefore, delayed payments arise.

7.0 Conclusions and recommendations

Firstly, the current study was aimed at investigating the existing payment practices and related issues within the construction industry. There are three types of payment issues prevailing in the construction industry: delays, incomplete and non-payments. Among these three issues the Sri Lankan construction industry suffers widely by the delay payments. Incomplete payments are not applicable because at the end of the project the contract price is paid and the deductions made in the interim bills are reasonable deductions. Non-payment is not a common issue under Sri Lankan context. The projects funded by local government face more delays comparing to private and foreign funded project. Corporate clients are considered as good paymasters than the individual clients. Final payment delays very often than retention and interim payments whereas advance payment very rarely delayed. The subcontractors are mostly affected party in the payment chain than the main contractors. The uncertainty in the subcontractor's payment is increased because of the combined uncertainty in payment behaviour of client and main contractor. Further, the subcontractors are in the bottom of payment chain and financially instable. Therefore, subcontractors are mostly affected party in construction industry. The study concluded that payment delay is most significant issue in construction industry; delays are critical in the projects purely funded by the local government; final payments are very often delayed; and subcontractors are the mostly suffering party in the Sri Lankan construction industry.

Finally, the research was aimed at identifying the causes of payment issues prevailing within the Sri Lankan construction industry. The clients, consultants and the contractors are contributing to top three causes: clients' poor financial management, delay in certification by the consultants and improper bills from contractors. Cost overrun and clients' failure to source the adequate funding prior to initiate the project were also recognized as significant causes contributing to delayed payments.

The research therefore suggest to procure appropriate security measures in the form of having a payment bond from the upper tier, separate form of contract to subcontractors and construction contract act. This would ensure that contractors get paid on time and thereby contribute to the success of the project.

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Identification of body adornment concepts in Sinhalese jewellery

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Abstract

Adornment is a beautification and embellishment, and an addition to the pleasantness and attractiveness, a decoration that is added to relieve plainness. The human form has been subjected to adornment from the past to the present and towards the future in many different methods and techniques making it the foreground for jewellery. The jewellery industry today has developed so much internationally that the trends and fashion of body adornment are shared beyond the cultures and the traditions. Certain practices of adornment have found places internationally so that present practices of adornment have become timeless concepts merging with the trends of the world. The art of jewellery, in the tradition seem to interestingly combine with principles of design that showcases the skill of material handling, relationship made with human form, from the view point of the aesthetics. The inspiration that has been derived for such creations from various sources and the unique originality that has marked in the Sinhalese jewellery will be identified, based on the principles of art and design. In the method of study, the relationships jewellery has made with human body form, and the aesthetical patterns that have created along the traditions had made, visible connections with the cultural patterns will be brought into topical discussions. In the conclusion it has been found out that ancient concepts that were deeply rooted in the traditional practices consists of ultra modern techniques that can be renewed for the use of the present day practices that they are concepts of timelessness.

Keywords: *body adornment, concepts, Sinhalese jewellery, tradition, culture*

1.0 Literature review

The adornment in many cultural languages carry the meaning of furnishing or rather equipped with, that also is essential for the validity. For example Coomaraswamy(1981)gives examples for adornment as anything which enhances the effect such as the mind by learning, elephants by mast, rivers by water, night by moon etc.,In the Vedic grammar and texts adornment carries the meaning of 'abundantly furnished with', (Karkala1971)a thing that corresponds to the sense of increacement and strength. In many cultures and civilizations, ornaments had never been identified as wasteful things or vain productions of human effort, but as a rather an empowerment of their beliefs and practices. In meaning, it carries a broader definition, making jewellery, a significant element in ornamentation among many other. Jewellery, evidently stand for a defined and specific need in ornamentation, clearly defining the purpose.

Research conducted by Johnson, Schofield and Yurchisin (2002) indicates first impressions are created by clothing, body modifications and body attachments. The study stated that form impressions or opinions are created on the basis of appearance of adornment and dress. According to Ross (2008) by appearance an individual announces their identity, shows their value, expresses their mood or process their attitude. As a summary it can be stated that adornment and clothing give a personal recognition about the wearer such as the social status, occupation, wealth, power, culture and religion among many other. According to Eicher(2008) each culture or society has an ideal image of what the male and female body should look like. It has been stated that these ideals shift with time and different trends. On a social level, bodies are used to identify individuals within a larger cultural and historical context. (Kaiser 1997, p97). According to Shusterman (2006) additional evidence for the importance for considering the body can be found in the field of somaesthetics, or the study of how we create performance through perception, cognition, action, aesthetic expression and ethical self fashioning-in essence, the relationship between body, mind and culture. It is observed that, the jewellery concepts of the Indian influences carry the emphasis on the shape and form of the human figure and its responses to climate, that it is believed that the origins of the body adoration seem to have had a longer history than the cloth on the body.(Untracht 1982) The interwoven links that had with the religious beliefs, the beliefs set with the unforeseen forces of the universe and planetary effects seem to have had strengthened the body adornment concepts emphasizing on human form. (Untracht1982) According to the literature survey conducted most of the studies relate to the skin marking with systems of body modifications that the research conducted on the body adornment concepts and discourses on their aesthetics could not be found.

2.0 Objectives of the study

One of the objectives of the study is to understand the structured typology that can be identified from simple earrings to elaborate head gear which will be presented along a detailed description of their art and design components. The

study would emphasize the body adornment practices particularly the developments occurred during the early period taking evidence from literature, sculpture and temple paintings. One of the most important objectives is to study about the timelessness of these concepts which can be brought in to renewed concepts of the modern day practices continuing the tradition.

3.0 Introduction

It can be observed that embellishment had always been an indication of a rich culture. It is understood that, the careful thoughts and synthesis made upon creating jewellery, unfold greater values and deep set roots of the culture. The intelligence, freedom of imagination and wisdom, nourished by the availability of resources and technological expertise are considered as the most important concerns, from which stem the valuable crafting of jewellery. Rudimentary stages of body adornment runs back to more than 200,000years ago to the times of the Homo Sapiens according to Thomas (1937). Curiosity and inquisitiveness and the observation qualities of man, for touching objects, collecting them and wearing them for various purposes had led to such practices of body adornment. It is important to observe that the natural quality and the built form of the human body has led to many of the creative development of body adornment that had evolved during the long stood traditions. The upright quality has helped man to do many things according to his wishes. Most importantly the independence of hands had given him accessibility, to reach out for things, assemble things, collect things, and to be craftier using the hands and fingers at the same time allowing the evolution of rings for fingers and bangles for hands. The upright formation has opened up to a greater typology in body adornment. Human body is significantly divided into several sections on the upright structure, as head, torso and the limbs. Particularly face is identified as an attractive feature around which much jewellery are worn. A closer study of human form reveals much complicatedness in the structure of the human anatomy including the sophisticated and delicate bone structure which allows a firm grip on the body. The ancient sculpture, indicate to us, a series of interesting concepts of body adornment of both, male and female forms. The perfect shape of the male and female forms adorned with jewellery that run along the surfaces of the human body dignifying the body shape to a greater extent. This paper focuses of such practices that had evolved during the early period of Sinhalese jewellery tradition examined on the basis of design and aesthetics.

4.0 Male adornment concepts

The various different Malaya, (neck ornament) girdles (hip Ornament), armlets and bangles indicate the in depth thought processes that go into the design of such ornament. Certain ornaments seem to be very prominent than the rest, placed in a higher supremacy. Such are the head ornament details which are distinctively different. Neck ornament and many other take place according to the beauty of the form. As indicated in the figure, certain neck ornament becomes very prominent than the others, indicating distinctive form and shape. With reference to the evidence gathered, certain ornaments like the 'ekavali' (the valuable string of pearls) is placed on the male chest that hangs from the neck, above all the other. The placement of the 'Udarabhanda' clearly defines the neck ornament and the hip ornament at the upper and lower levels of the human form.

Characteristics of male ornament in line with male body contour

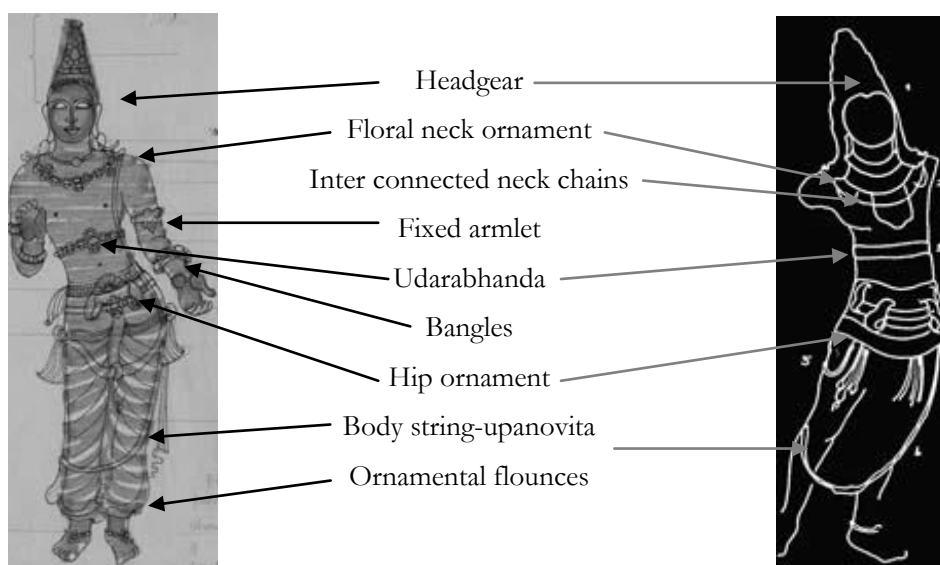


Fig -01 Illustrations from stone sculpture. Source - Author

5.0 Design concepts adopted for neck ornament design

Certain necklaces adorn the shoulder area as girdles with connection made with the tassels. The order is found as the throatlet, Malaya and the chain at the lowest level. Chain is sometimes found connected to 'channavira', the chest ornament. Particularly in the male adornment concepts the lowest chain has been identified as a thick band that connects and passed through creating a broad entwined collar like effect that has found to be unique in the Sinhalese neck ornament concepts, particularly in the male jewellery. (Coomaraswamy 1956)

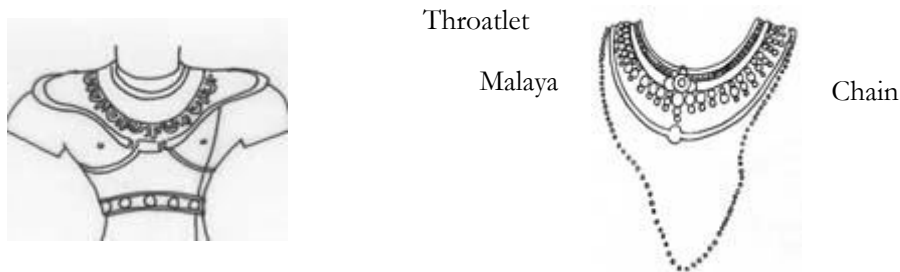


Fig -03 Neck ornament details from Polonnaruwa
Source – Author

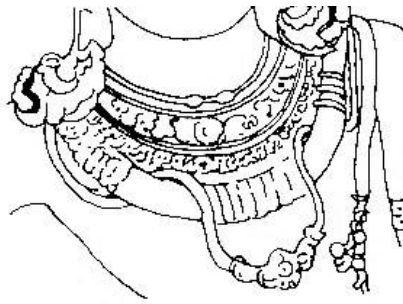


Fig -02 a & b Princely ornament sculpture. From Tiriyaya 7th, 8th C. Anuradhapura
Source – Author

The narrow waist of the male form is elegantly wrapped in different sequences of hip ornament, at different levels, identified as 'katibhanda', 'bandana' (bands), and 'mekhala' (girdles). The inner faces are connected with a net work of ornament that is defined to have detailed with dangling bells at different intervals. These net works of ornament, that define the male hip area, seem to fall down to the knee level in falling strings that may have created pleasing motions with the body movement. Some of the most dignified characteristics have been identified in hip ornament in the Sinhalese tradition. There are 03 basic kinds of hip ornament, namely identified above, as 'Katisutra', 'Bhandana', and 'Mekhaladhama'. 'Katisutra' bears the characteristics of a tightly fixed ornament, tied round the hip. 'Bhandana' has the motif incorporated, to avert the evil eye. Generally face of 'kubera', and dragon face etc. 'Mekhaladhama' contain long tassels with chain, pearls hanging in tiers and folds from the main band.

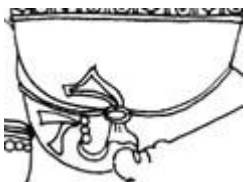


Fig -04 'Katisutra' depicted on a guard stone. Worn at the navel.



Fig -05 Pearl tassels found at the hip ornament



Fig -06 Tightly worn hip bands with 'Kubera' face to avert the evil eye



Fig -07 In the Sinhalese ornament the tassels and folds are indicated in decorative bands falling over the thighs in loose motions



Fig – 08 Details from Polonnaruwa sculpture. Source - Author

Various kinds of hip ornament are shown with falling tassels made out of fabric or chains. Such variations are shown in the diagrams below, in Sinhalese practice.

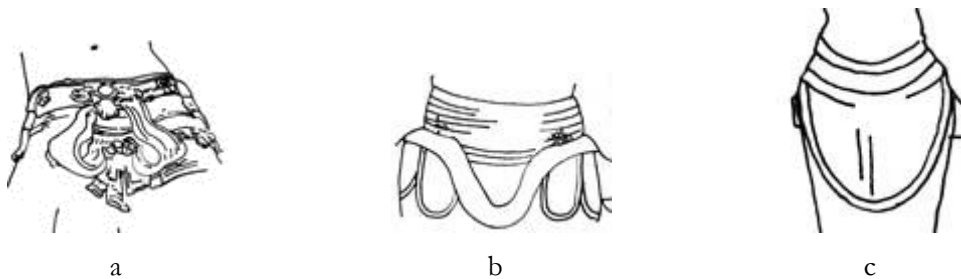


Fig -09 a,b,c - Examples from Polonnaruwa sculpture. Source – Author

6.0 Concepts of female body adoration with jewellery, in early tradition

The earliest Sinhalese sculpture signifying ‘Yakshi’ and ‘Nagini’ figures denote the higher standards achieved in the art of creating beauty in female sculpture. The lines denote a classical simplicity, highlighting a form of the female figure. Lines of neck, shoulders, upper arms and lines of the breast and hip area is highlighted with soft curves.



Fig -10 The early most wooden sculpture, early Anuradhapura period
Source – Schroeder 1990



Fig -11 Nagini sculpture
Source – Schroeder 1990

The earliest records indicate to us, the wearing of the elaborate hip ornament identified as ‘Mekhala’ in literature that had been a popular practice from the early traditions, of the Sinhalese ornament. Such ornamental details as expressed in the Sinhalese sculpture vary with degrees in exaggeration depicted in different sculpture. Particularly the Indian female figurative details indicate to us, the exaggerations of hip ornament detail, deviating from the classical simplicity of the Early Sinhalese practices depicted in the sculpture.

The 'Mekhala' (hip ornament) in Indian and Sri Lankan sculpture



Fig -12 Example from Sanchi, North Indian sculpture. Source Chauley 1998



Fig -13 GajaLaksmi at Vahalkadapillar. Archaeology museum Ampara. Source Schroeder 1990



Fig -14 Stucco figurine of North Indian origin found from Anuradhapura source Schroeder 1990



Fig -15 Kubera figurines from Anuradhapura Source Schroeder 1990

7.0 Aesthetics of jewellery worn to decorate the chest and shoulders

According to many evidences the perfect form of the female figure depicted with high breast, narrow hip and dignified formation of the female form denoted with classical lines has been continued in the Sinhalese tradition from the early Anuradhapura period in the past history. The upper areas of the female form that includes the neck, shoulders and the breast is adorned with ornament from tightly fitted choker ornament to the hanging pendants that rest on the mid plane of the breast, accompanied by the fitted armllets on either side of the arms. Various expressive details from the elaborate Sinhalese literature work can be taken as examples on the narration of the beauty of the female figure in ornament. Particularly the breast is compared with a couple of swans, and the stately arms to the well formed trunk of an elephant. A number of necklaces that adorn the neck area at different levels are a commonly marked feature in the female ornament. The mid plane that forms from the neck, Shoulders, upper arms and the breast has been the foreground for the adoration with necklaces that is well expressed, particularly in the Sigiriya jewellery.



a



b

Fig -16 a,b - Examples from Sigiriya paintings 5th century A.D Source – Chutiwongs 1990

Breast Ornament detail

Gracefulness and beauty highlighted with jewellery on the female breast in various different ways can be a feature identified in jewellery.

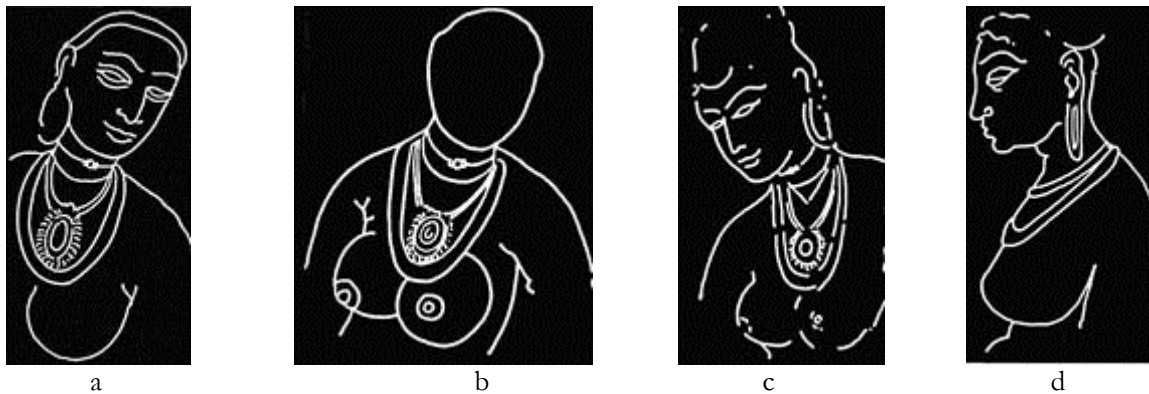


Fig - 17 a,b,c,d - Sketches & illustrations from Sigiriya paintings by author

The gem studded pendants and golden strings of jewellery that encircle the soft curves of the female chest, is particularly highlighted in the damsel paintings of Sigiriya, marking a classical advancement of art in the Sinhalese tradition.



Fig -18 Shakti sculpture from Abayagiriya
source 'Sanskritipuranaya', April – June 1999



Fig -19 Sculpture from Sigiriya
Source 'Serendib' Sept – Dec 1988

8.0 Head Dress as supreme of all jewellery

The arrangement of jewellery as head ornaments had evidently been a unique tradition that is shared by the cultures of the Indian origin. It is evident that this had resulted with the culmination of philosophical and environmental conditions. The anatomical characteristics too have governed as a decisive factor in this process. Anatomically human head demands the attention and attractive feature on human form. This has been absorbed in to the philosophy of life of man making it an important part in the individual as well as social life concepts. Most interestingly the hair is generally arranged high up, away from the face neatly combed back for health and comfort reasons. As a result this has been identified as a regular practice in the tradition.

Use of natural coil forms of hair with gem studded jewellery.

Particularly in the Sigiriya jewellery, the high up arrangement of hair of the damsel figures in coil forms done up on the head using natural flowers, supported by forehead ornaments, and studded gem structures on high up on the head. Some of the decorated flowers seem to fall down on the back, creating elegant natural forms that give originality to early Sinhalese aesthetics of arranging the hair.

Jewelled crowns supported by 'Jatava'

It is observed that clothed jatava is used, on the head gear as the pedestal on which the ornamental structures are fixed in the hair arrangement, bordered by a thick ornamental band of metal. The figure indicates such arrangement indicated in the Sigiriya figures that are part of the classical arrangement in the body adornment concepts.



Fig -20 Bodhisatva sculpture
source – Schroeder



Fig -21 Ornamental head gear
Source –Chutiwongs 1990

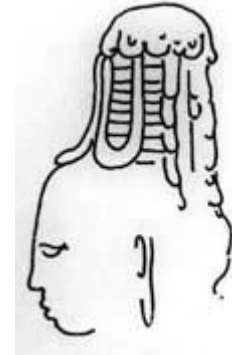


Fig -22 Head gear with Coil forms.
source Schroeder 1990

Heavy ornamental work with foliage patterns, and gem studded structures

One can come across unique traditions in the Polonnaruwa period where one experiences tall structures of enormous patterns and detail that had originated from the South Indian traditions but developed a language on their own. Enormous amount of organic shapes are incorporated in these structures and that their style differ from those of the classical types found in the Anuradhapura period with evidences.



a



b

Leaves, flowers, foliage and
gems used in headgear.

Fig – 23 a,b - Illustrations from Sigiriya and PolonnaruwaThivanka image house.
Source - author

9.0 Ear ornament design

It is identified that, certain principles had been adopted in the ear ornament design in the tradition taking in to consideration the physical features, the anatomical placement of the ear. Ear had been given much prominence using its anatomical flexibility as an advantage in the development of the ear ornament. Certain primary forms of jewellery had been used in the tradition as a result, of this unique development.

Anatomical placement of the ear, on human form

It is important to note that the physical build up of the ear, had naturally given rise to the adornment concepts from the developments occurred in the early beginnings of man. Particularly the ears that are at either side of the head had enabled the framing of the face. Also certain anatomical features have led to the adorning of the ear in many ways.

The elongated ear formation as a tradition in practice had been most clearly identified in the Indus valley practices. Certain examples where the deformation takes place by wearing jewellery with weight can be experienced even today among the traditional practices of India. Particularly in the Indian practices, the ear is pierced at several places along the lobe and cartilage structure to insert ornament in them.



Fig -24 Elongated ear with weight devoid of ornament
From Sigiriya paintings. Source – Author

Elongated ear ornament with weight

It is noted that in the early traditions, the ear ornaments were in heavy forms and shapes, that were worn along the stretched ear lobe. Several of these shapes were believed to have made with amulets. Evidence is obtained from early temple paintings, sculpture and archaeological excavated objects.

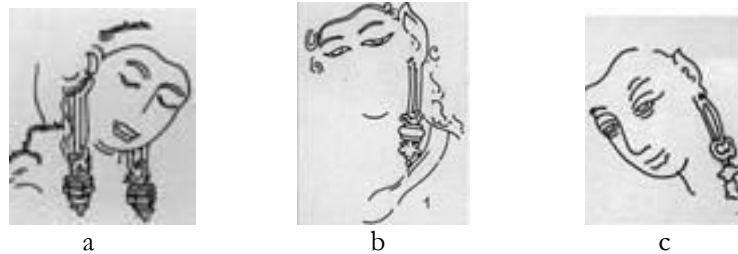


Fig -25 a,b,c -Illustrations from ‘Thivanka’ image house, Polonnaruwa,

Coiled Forms

Coil form fitted perfectly into the enlarged ear lobe had been a marked tradition in Sinhalese design. Single, double, triple stripes of form is coiled and had been made as earrings. Also found are the natural coils of conch shell, ivory spirals, calc spirals in different forms. Particularly spirals are artistically depicted in Anuradhapura and Polonnaruwa sculpture.

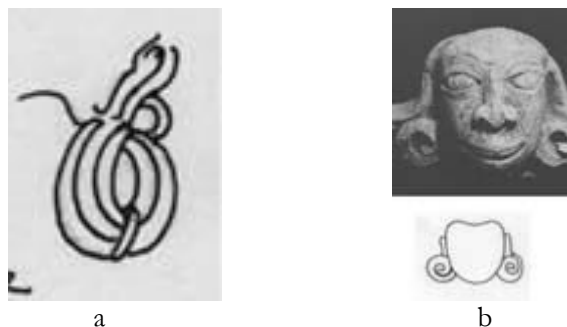


Fig -26 a,b -Coil forms from Polonnaruwa sculpture and temple paintings
Source Schroeder 1990

Discal earrings

Large circles as discs had been in the tradition from early periods of Sinhalese ear ornament. One of the most classical discal ornaments can be found from Sigiriya, paintings and sculpture. These large circular ornaments depicting a rim is believed to be derived from, the practices of Orissan culture according to Sivarama a. y, (1981), which had evidently

continued to later Chola developments. They are believed to have been made with gold foil, also identified as 'patrakundala' which are either made from 'palm leaf', 'dantapatra'/ivory, or in thin sheets of gold.

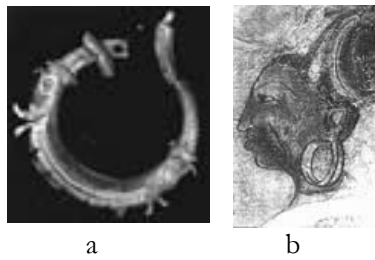


Fig -27 a,b - Discal earrings from Sigiriya Source-Chutiwongs 1990

10.0 Adornment of the hands with Jewellery

Human anatomy of the hand

In the chronological order, the bangle jewellery has an important place in the early tradition, considering the adornment of the hand. Bangle jewellery has been considered as one of the early forms signified with movement of the hands. Hand as a prominent feature in the human body, having movement and dynamism indicated with fingers, the slender muscle formations has given both male and female jewellery, a significant place. Traditionally bangles are known as 'valaya' meaning an 'encircle'.

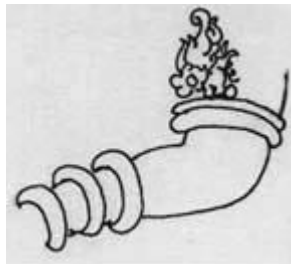


Fig -28 Illustration from Thivanka image house

Connected bangles

Some are found as a series of singular bangles connected into one form, made out of metal, and studded with gems or decorated with foliage design. Given below are some of these bangles found from Anuradhapura.



Fig -29 Illustration from Sigiriya paintings

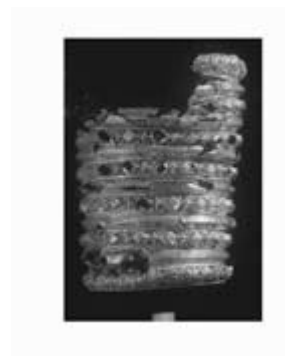


Fig – 30 Supreme classical example for bangle Jewellery, found from Abayagiriya, Anuradhapura
Source 'Sanskritikapuranaya',
1996 April June

Bangles

Various intricate foliage patterns are carved in the bangles, found in different forms and shapes.

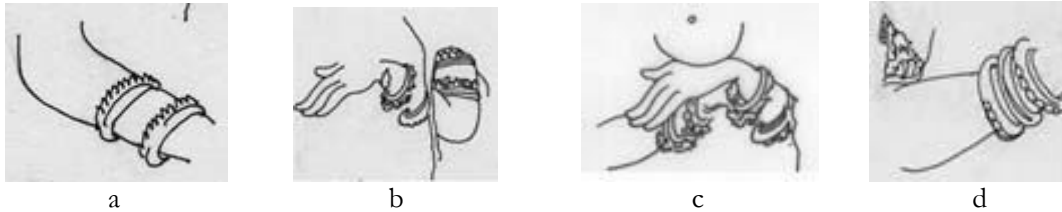


Fig -31 a,b,c,d - Examples from Polonnaruwa, Tivanka image house .Source -author

Conclusion

Jewellery, undoubtedly seem to have materialized out of the human love for beauty and self adornment. The underlying causes of jewellery seem to relate to the apparent complexities of human nature. Human body evidently becomes a foreground for jewellery, because of its genuine characteristics. Man had gone to extensive detailing using his imagination to give beauty, comfort and function to the things that are created as body adornment. The manner of orderly arrangement in the evolution of jewellery, particularly in the early periods of Sinhalese tradition, during the Anuradhapura and Polonnaruwa periods can be depicted with the evidence gathered from various different sources. The orderly manner that is indicated in these arrangements depicting a clear hierarchy of jewellery for the particular segments of the human form, most interestingly combines with the relative social norms, rituals and functions of the human life. The chronological order, indicate a distinction of the development of jewellery, and its achievement of advancement in creativity. Some forms of practices have been repeated absorbing in to a traditional practice up to the present day. This has been achieved by giving a hierarchy, defining a specific area, order of placement in a variety of ornament on the human form. Interesting series of concepts and principles are found from the traditions, in the practices of jewellery, worn on the human body. These associations had been made as part of recognition, identity, design and beauty. In the Sri Lankan history, we come across early period traditions where much of the Indian influences had prevailed in body adornment. The body was adorned with jewellery having placed carefully and artfully, jewellery along the contours of the human form in the most pleasing manners. Particularly the change of adornment concepts that binds the human form have evidently changed due to the beliefs prevailed in different time periods. The natural environment conditions, the availability of materials, the beliefs and the functional aspects have given rise to interesting developments in the history of jewellery, in the traditions that is centered on the human body form.

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Potential Brokerages in Relationally Integrated Value Networks (RIVANS) for Total Facilities Management: Literature Findings

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Abstract

The collaborative supply chain networks in relational contracting modes have gained considerable attentions in recent decades as an essential prerequisite for enhancing business performance. Accordingly, integration of Project Management (PM) and Facilities Management (FM) phases of facility lifecycle through a collaborative network of stakeholders has been recommended as value additional strategy for the built environment professionals. Such value networks are called relationally integrated value networks (RIVANS) that operate extending PM and FM towards Total Facilities Management (TFM). TFM involves effective transferring of information, material, and services between PM and FM phases while sharing common goals among all stakeholders in entire life cycle of a facility. However, weak integrations among stakeholders have identified as one of the greatest barriers to form RIVANS between stakeholders in both phases and hence poor performances during FM phase are experienced. TFM provides a holistic approach through RIVANS to bridge the PM phase and the FM phase in the lifecycle of facilities as a favourable approach. Therefore, this paper aims to integrate these two phases through RIVANS by linking stakeholder of both phases. Study found that there are problematic "structural holes" that exist in these networks, which impeded the flow of information, material, and services and are short term oriented. Long term oriented value network appears to be favorable in facilities lifecycle to bridge the two phases through a common set of goals. Hence, the paper concluded that there is a brokerage potential of client's facilities manager and project manager to bridge two network structures while strengthening structural holes. The brokers help to transfer material, information, and service between different stakeholders while enhancing better value through common goals.

Keywords: Integration, Facilities Management, Value Networks, Brokerages

1.0 Introduction

Facilities Management (FM) has become recently emerged significant proponent in the built environment as a profession by which facility could effectively support efficient and effective service delivery throughout its life cycle. Barrett and Baldry (2003) defined Facilities Management as an integrated approach of maintaining, improving, and adapting the buildings of an organisation in order to create an environment that strongly supports the primary objectives of the organisation. Thus, FM is concerned with providing satisfactory levels of services that have been agreed with customers in the most cost-effective way for present and future outcomes (Lepkova, and Zukaite-Jefimoviene, 2012). However, effective service delivery depends on the magnitude of the decision making taken placed at the project planning and developing phase of the building life cycle, towards providing expected levels of service (Ling et al, 2014). In this regards, interrelationship between FM phase and Project Management (PM) phase has identified as an essential requirement for delivering continuous and satisfactory services to the occupants. As such, most of the researchers also have mentioned that considerations for FM should initiate right from the PM phase (De Silva et al, 2014).

Traditionally, supply chains in PM and FM have been operated as independent chains, with minimal collaboration with one another (Kumaraswamy et al., 2012). These two phases involve with number of stakeholders who participate in two different supply chain networks with different motives. Kumaraswamy et al. (2004) further highlighted that interaction and communication between these two phases are usually limited in traditional procurement approaches where transactional force are very limited, resulting in weak collaborative supply chain networks. Therefore, managing client requirement becomes a complex process which is crucial to the successful delivery of construction projects. However, creating relational value networks (RIVANS) by integrating these supply chain networks is a key drive towards achieving Total Facilities Management (TFM) to satisfy the client need. Famakin et al. (2012) highlighted that value networks with common values shared among project stakeholders that focusing on optimising relational

integration, generate synergies Moreover, it has become increasingly important for PM and FM stakeholder to maintain long term interaction due to the needs of client/occupant/owner (De Silva et al, 2014).

PM stakeholders may require to link with the FM stakeholder as a holistic approach for facility life cycle through common goals in delivering efficient services to end users. Further involvement of a broker between stakeholders could be supported to reinforce the links between weak relational contracts. Hence, this paper structured to investigates the relationally integrated contracts between FM and PM stakeholders and identify potential brokerages that exist in these networks to create strong collaboration, which impeded the flow of material, information, and services.

The paper aim is to develop a common network by linking the stakeholders in PM phase and FM phase supply chains by conducting a literature survey. Firstly, paper addressed the concept of RIVANS and potential brokerage theory. Collaborative networks in PM and FM for brokerage potentials are discussed and further collaborative network in TFM is proposed with the brokerage potentials.

2.0 Research Methodology

The objective of this paper is to develop a hypothetical relationally integrated value network, expanding over PM and FM using a literature survey. Aiming that, it is required to establish potential brokerage in PM and FM value networks. Therefore more than 70 journal papers published during 2000 to 2013 were reviewed to investigate the theoretical scenarios for RIVANS. Those papers were mainly from five journals (Table 1).

Table 1: Journal Articles

Journal Name	No of papers
Facilities	20
Journal of facilities management	25
Supply chain management: an international journal	10
Engineering, construction, and architectural management	12
Journal of financial management of property and construction	8

In addition, conference papers, published books and other related journal articles were reviewed to attain the objective of the study.

3.0 Literature Findings

3.1 Relationally Integrated Value Networks (RIVANS)

Interaction and communication between PM and FM phases are usually limited in the traditional procurement approaches. Therefore, unrealistic expectations, incomplete requirements, insufficient resources/schedule, lack of management support, poor planning, changing requirements, and lack of users' involvement were highlighted as common problems in maintenance of built facility (Yu and Shen, 2013). Further, with the increased attention on customer satisfaction, sustainable buildings, life cycle cost, flexible designs, designing and constructing for maintainability, interaction and working relationship between PM and FM has become increasingly important (Ling et al, 2014). Therefore, Kumaraswamy et al., (2010) proposed RIVANS as a solution for a holistic conceptual framework for "relational integration," where stakeholders are engaged in cross-linked value networks which extend beyond the typical structural integration approaches such as in procurement modes like design – build or design build-operate. RIVANS identifies better values of the entire stakeholders/network (including the client, consultants, contractors and suppliers in the supply chain), and build better relationships, mostly by jointly focusing on, and working towards such common shared goals. RIVANS can be seen as a viable vehicle to mobilize for addressing persisting shortfalls in achieving overall value through encouraged increased focus on the collaborative elements of design and construction (DC) of project management (PM) phase and FM phase (operation and maintenance) of facility. However, the diverse nature of participants with different backgrounds, expertise, and values can lead to difficulties in achieving an integrated collection of creativity, shared understanding, and common goals (Sebastian, 2007; Emmitt, 2007). Further, both phases are fragmented and hence, only short term oriented relationships are existed.

3.2 Brokerage Potentials in value networks

The social capital was originally used to describe the relational resources, embedded in cross-cutting personal ties. Later research has applied the concept to a broader range of social phenomena, including relations within and beyond the firm (Tsai and Ghoshal, 1998). For long there have been two approaches to social capital (Vlies and Maas, 2009):

- (i) The network closure approach focuses on the density of the network,
- (ii) The structural holes approach focuses on the gaps between several dense networks

In particular, Burt's theory of structural holes views that organizations are not remain just in terms of the tight connections within their social structures, but also in terms of the "holes" where connections have failed to form. Such holes provide opportunities for socially entrepreneurial individuals to play bridging roles in the organization, linking to disparate people or groups who are otherwise not interacting with each other. The argument is that individuals whose connections bridge such holes tend to do particularly well professionally, and this argument has been supported by empirical studies of managers in large corporations, correlating an individual's success with this type of bridging activity (Burt, 1992). However, structural holes disrupt the flow of valuable information in a project which provides opportunities to those who can re-make (broker) those connections to achieve a smooth flow of information, material, and services (Burt, 1992, Kuratko et al., 1990). Therefore, by spanning structural holes brokers can perform an "intrapreneurial" role within and FM and PM phase, by leveraging social capital from the new non-redundant connections between FM and PM phases of the facility. The strategy guided by brokerage involves locating a position at the edge of two groups, and building relations between dissimilar people (Burt, 2000).

For example, if a broker sits between two other actors and controls the flow of information between them, then they are in a powerful position. Baker and Obstfeld (1999) argued that brokers tend to employ two distinct types of strategies in reconnecting organisations: "disunion" and "union" strategies. In the disunion strategy, the broker pursues the active separation of disconnected actors therefore becoming a bridge between two disconnected actors but not allowing them to interact directly. Conversely, in the union strategy, a broker closes the network holes between two disconnected actors enabling them to communicate directly or through a common third party. In reality, a combination of both approaches tends to be adopted. However, paper attempts to address the brokerage potentials in TFM by connecting stakeholders in both PM and FM phases.

3.3 Collaborative Network in PM and Brokerage Potentials

The construction industry characterised with high fragmentation, conflicts and disputes compare to other industries (Dainty, Millett, and Briscoe, 2001). Hence, coordination and cooperation is frequently practiced in construction industry through formal supply chains or other relational contracts. Further, there are some lasting networks in the construction industry to fulfill their end objectives. From a social capital perspective, the construction industry is a large sector with little network closure and many structural holes. The lack of network closure results in the short-term orientation. Further, fragmentation and project based contacts result in many structural holes (Vlies and Maas, 2009).

In general, there was a preference for less structured or informal partnerships and loose alliances that were not moderated or prescribed by formal contractual arrangements in construction industry (Briscoe and Dainty, 2005). Construction supply chain on larger projects typically involves hundreds of different companies supplying materials, components and a wide range of construction services (Dainty, Millett, and Briscoe, 2001). There are three types of CSC: the primary supply chain, which delivers the materials that are incorporated into the final construction products; the support chain, which provides equipment and materials that facilitate construction, and the human resource supply chain which involves the supply of labor (Muya, Price and Thorpe, 1999). According to the Xue et al (2007), construction supply chain consists of all the construction business processes, from the demands by the client, conceptual, design and construction to maintenance, replacement and eventual decommission of building, and organisations, which are involved in the construction process, such as client/owner, designer, general contractor (GC), subcontractor, supplier, consultant, etc.

A typical construction supply network has main contractor at centre of the hub, with links to the client, main supply agencies and to the both design and any specialist management service, all of which are provided externally (Dainty, Millett, and Briscoe, 2001). According to the Xue, et al, (2005) construction supply chain involves key members of construction supply chain, including client/owner, designer, contractor, subcontractor, and supplier which presents in Figure 1.

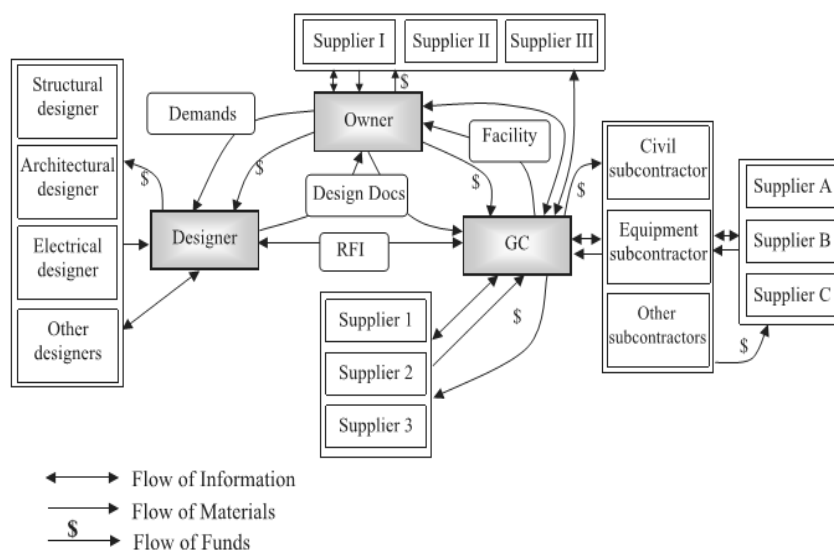


Figure 5: A typical Construction Supply Chain
(Source: Xue, et al, 2005)

Flow of material, information, and funds between various stakeholders in construction industry illustrates in Figure 1. Contributions of different stakeholders including clients, architects, consultants, contractors, and planners can make a long been recognised project. Further, Xue et al (2007) showed the different communication transferring efficiency in construction supply chain (refer Figure 2).

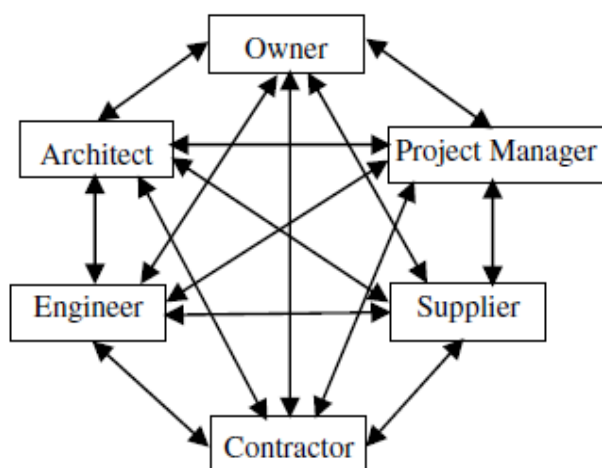


Figure 6: Communication in CSC
(Source: Xue, et al, 2007)

Accordingly, there are various types of relationships or interactions between PM stakeholders. Most long-term relationships were formed only with principal contractors and clients who were reluctant to fully engage with subcontractors and suppliers (Briscoe and Dainty, 2005). Nobbs (1993) mentioned that the contribution of sub-contractors to the total construction process can account for as much as 90 per cent of the total value of a construction project. But, most work undertaken in construction partnering has been largely main contractor-client based, with little or no mention of adopting partnering with subcontractors (Matthews et al, 2000). The main contractors were usually left to forge their own relationships with the subcontractors and, often appeared to be insufficient trust to allow any formal partnering of an enduring nature (Briscoe and Dainty, 2005). According to Briscoe et al, (2001), main contractors frequently changed suppliers, often failed to share strategic information, provided some poor feedback to these suppliers, and commonly made late payments. Similar problems were

observed in a study by Thorpe et al (2003) where supposedly “preferred” subcontractors were disadvantaged by some supply chain practices.

Further, prime contractors increasingly depend on their suppliers, both for realizing projects and for achieving required performance in the projects. This increasing dependence on the prime contractors provides opportunities for contractor-supplier cooperation and emphasizes the importance and significance of managing suppliers (Voordijk and Vos, 2012). According to the Xue et al (2007), there are no direct relationships between owner-subcontractor, owner-supplier, designer-subcontractor, and designer-supplier. Ceric (2010), mentioned that project owner, contractor, and their project managers play key roles in all construction projects. Moreover, project managers, involved in construction projects are typically professionals concerned with a wide variety of construction-related disciplines.

Moreover, different types of client-design consultant relationships are delineated. According to the Margaret et al (1993), relationships that span a number of years entail a high degree of rapport between client and design consultant that are particularly beneficial. Long-term relationships enable design professionals to gain a deep understanding of the client’s business and engender mutual respect and trust between the client and design professional, which facilitates the

creation of effective design solutions. Siva and London, (2012) further stated that architect and client relationship allows to understand the culture and norms of the new environment for both parties which would create better confidence in project continuation.

Further, findings of the Xie et al (2010) showed that project manager, lead quantity surveyor (QS), are the central actors in the communication network, and are well connected to the rest of the project team, demonstrating an important role in the project initially. Thereafter, the design coordinator from the architect side becomes the central actor in design phases and design team members have moved towards the centre and the QS away from the central role to manage the construction process (Xie et al, 2010).

Humphreys, Mathews, and Kumaraswamy, (2003) described, main contractor to establish qualified partners with subcontractors that yields to all the agents in the supply network and produces significant improvements in collaborative working. Wan and Kumaraswamy, (2012) revealed poor coordination and frequent design changes and/or errors at the pre-installation stage of building services projects could be solved adopting intra-inter dependent teamwork concept. Further authors mentioned to establish the post of building service coordination facilitator who is responsible for overall planning, controlling, and coordination of the design and construction teams to ensure that decisions are made in the best interests of the project. Thereby, the service coordination facilitator can be act as the project manager at the design and construction phase of a facility.

The literature review identified various studies exploring client-designer relationships, project manager-design team relationships and architect-client relationships. However, the diverse nature of participants with different backgrounds, expertise, and values can lead to difficulties in achieving an integrated collection of creativity, shared understanding, and common goals (Sebastian, 2007; Emmitt, 2007). This approach involves clients, designers, main contractors, and subcontractors working together as a unified team, rather than as a disparate collection of separate organizations (Latham, 1994; Egan, 1998).

Accordingly, literature findings developed collaborative network for project management phase as illustrates in Figure 3. According to the Figure 3, network consists with client/owner, architecture/designer, contractor, project manager, subcontractor, QS, engineers, and project manager. All the stakeholders are centered to the client's project manager who typically fulfills the work on the project on behalf of the client. Project manager required to interrelate with all the stakeholders to attain project objectives. Hence, all stakeholders are eventually worked for the set of common goals. It is also clear that the project manager can be act as the broker who would strengthen the link of each stakeholder. Client's project manager plays a central role to coordinate the designed and construction phases.

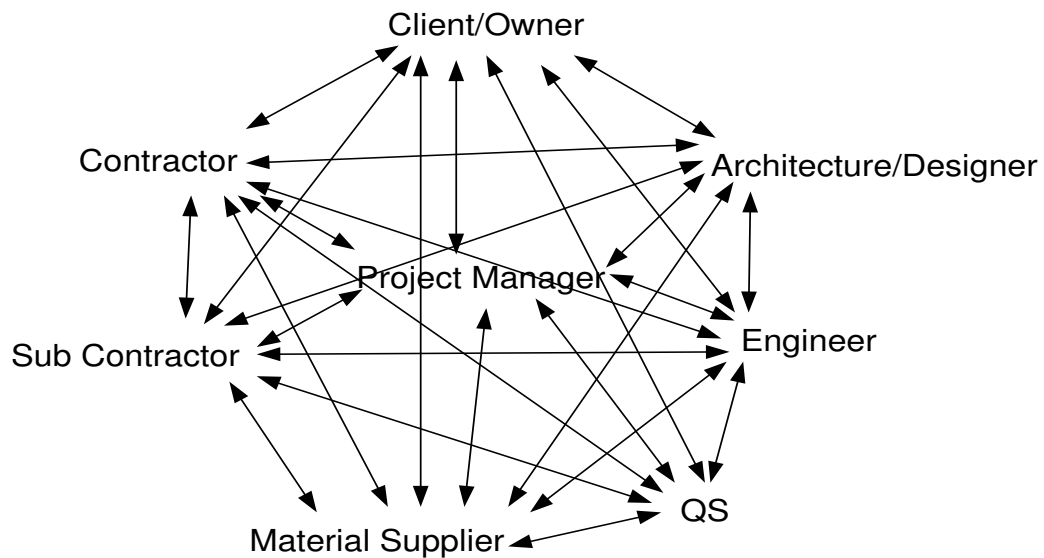


Figure 7: Collaborative network of PM

3.4 Collaborative Network in FM and Brokerage Potentials

Many FM authors describe, built environment as fragmented (Tuomela, et al, 2005) and involved with a number of stakeholders who are fulfilling various needs of its functional requirements. Coenen, Alexander and Kok, (2013) mentioned that FM is considered as a network of relationships which creates perceived value amongst these intra-organisational stakeholders. The relationships in FM are built with the co-creation of services, through integration of

resources and effective communication (Lehtonen, 2006). Thus, Lehtonen, (2006) noted that collaborative relations in facility services management seem by nature to be more operational than strategic under following options:

- Purchasing volume
- Only some relation-specific investments
- Low level of interdependence
- Service provider replaceable if necessary
- Benefits not shared equally, no risk sharing

However, it is recognised that the importance of the service delivery is significant for the client's or end-user's business, and therefore it is essential to share sensitive and strategic information, purchasing high volumes, or the manage the purchasing situation (Lehtonen and Ventovuori, 2006). However, the manner in which the individual stakeholders and their units affiliate and connect to the collaborative network can be analysed in many ways (Tuomela and Salonen, 2006). Gronroos (1996) suggested that partnerships and networks are formed with horizontal and vertical connections. Vertical connections of the network, refer to buyer-seller coordination and horizontal connections represent functional activities. Thus, Barrett (2000) showed that the collaborative networks should have strategic connections with strategic level of facility services management and operational connections with different functional units.

Moreover, Then (1999) revealed that FM as an integrated resource management framework that spells dramatic shifts in competencies for both the demand side (purchasers of facilities and services) and the supply side (suppliers and service contractors). Therefore, a demand perspective should focus on internal stakeholders in terms of building users, or broader, users of the facilities that are part of the responsibility of FM (Coenen, Alexander, and Kok, 2013). Authors, identified the most relevant key stakeholders in demand side perspectives, as clients, customers and end-users where strong relationships in FM are built through the co-creation of services, through integration of resources and through effective communication relationships (refer Figure 4). Jensen (2010) deliberated the supply-side perspective of value in the FM and explained the different ways that FM can add value to a core business. The stakeholders divided into owners, staff, customers, and society. Further author stated that the interests of different stakeholders such as the organisation itself (policy makers, staff, controllers, and facilities managers), owners (investors, shareholders), visitors, suppliers, customers, and society (local, regional, national, global) need to be considered in FM phase.

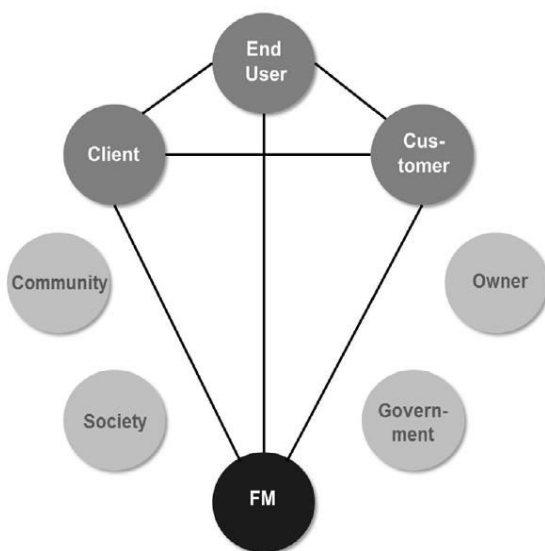


Figure 8: Stakeholders in FM
(Source: Coenen, Alexander, and Kok, 2013)

Tuomela (2003) introduced functional levels into the network, which divide the network into hierarchical levels of strategic clients, network integrators, and service units. Tuomela, et al, (2005) developed a model or a framework (refer Figure 5) for interaction of building in triadic networks that is derived from a knowledge base that explained the requirements of core businesses, key real estate and facilities services attributes and options evaluation to meet dynamic changes. The case study indicates that the networks of building users, owners, facilities management parties, and service providers can improve their interaction and cooperation with multilevel interaction building, mutual orientation building in groups and formation of boundary-spanning roles (Tuomela, et al, 2005).

Further, the authors indicated that stakeholders in the middle management are the network integrators focusing on operational management at the level of the decentralised business unit. These network integrators consist of in-house and external FM, PM and service providers, and part-time contract managers who function as an authority hierarchy between the centralised management and local service providers.

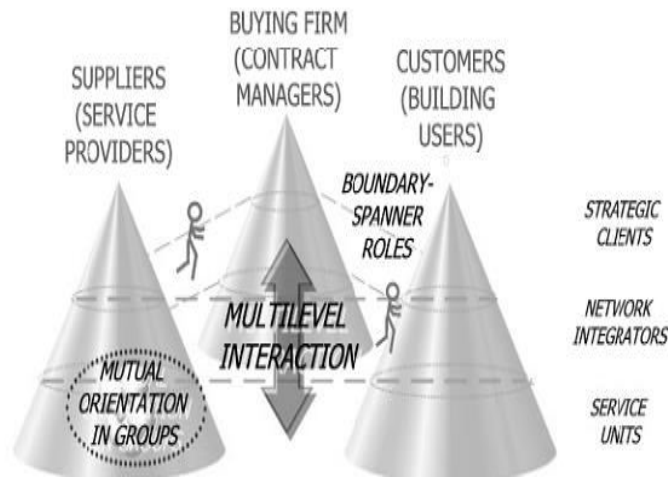


Figure 9: FM network
(Source: Tuomela, et al, 2005)

Moreover, Tuomela and Salonen (2005) formed a network with integrative organisational levels of strategic clients, network integrators, and functional service units, integrating stakeholders such as owner and service providers in the external networks. Authors, further mentioned that these networks can be used to understand the complicated roles within the built environment, considering the interaction needs of different functions. However, Heng and Loosemore, (2013) identified pools of disconnected information flows in these networks due to complexity functions in the built environment. For example, the authors mentioned that in hospitals, only a relatively small number of powerful departments play important brokering roles in connecting stakeholders.

It has been noted that the facilities management environment consists of network actor roles of service providers, building owners as contract managers, and the end-users of services. Figure 6 presents the findings of key literature survey where findings of the key players in FM supply china. According to the Figure 6, the client’s facilities manager will be the key player of the network who will interact with all the stakeholders. The network is considered as client facilities manager coordinate the FM functions with the support of in-house and outsource staff (service provider).

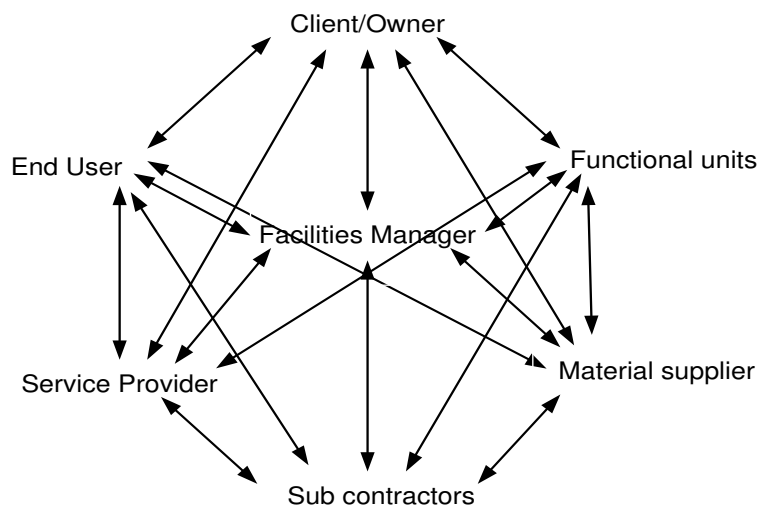


Figure 10: Collaborative network of FM

3.5 Collaborative Network in TFM and Brokerage Potentials

The development and use of built facility entails two major supply chains of project management and facilities management. Previous sections discussed the collaborative networks of those two phases separately. However, the generic problems with these networks are short term oriented and usually as strong as their weakest link. Nevertheless, Total Facilities Management required long term relationships which need to initiate from the PM phase and remains till

lifecycle of the built asset (De Silva et al. 2014). According to the Kumaraswamy et al (2012), sustainability and lifecycle imperatives, benefit from closer linkages, by integrating both supply chains given their intuitive interdependencies.

It is also found that same stakeholder in PM phase is performing various roles in FM phases. Brochner, (2007) studied the role of the contractors when they are providing FM services and identified that there is a unique project culture, typical of construction, which is difficult to reconcile with the emphasis on long-term relationships in FM contracts. Further, when, contractor need to enter FM phases with the strategy that includes continuous FM service delivery, associated with better learning of what makes their customers satisfied, should increase the potential for having more loyal, recurrent clients for construction projects.

In addition, David et al, (2010) and De Silva et al (2014) noted the importance in participating facilities manager in design and construction phase of a built asset project. The authors demonstrated that too often, facility managers are neglected in the design phase. It is clear whether this is out of deference to architects or because they are unaware of the design cycle or how design firms work. However, the proper relationship between the facility management team and design team need to be there in order to accomplish successful project.

Integrating FM phase with the PM phase of the facility would create long term relationships with the project team and those relationships could be prolonged to the facility operation and maintenance phases in terms of information, material, and service. Hence, network integrators would be contributed to a common value path where there will be less fragmented and less conflicts, especially latent defects (De Silva et al, 2014).

Therefore, a conceptual REVANS network for TFM of a built asset can be formed linking all stakeholders in the lifecycle of a facility (Figure 7). In a client led network, either project manager or facility manager can be act as the broker between two integrated networks for the betterment of the life cycle of the facility. Following Figure 7 shows the conceptual collaborative network for client led interactions.

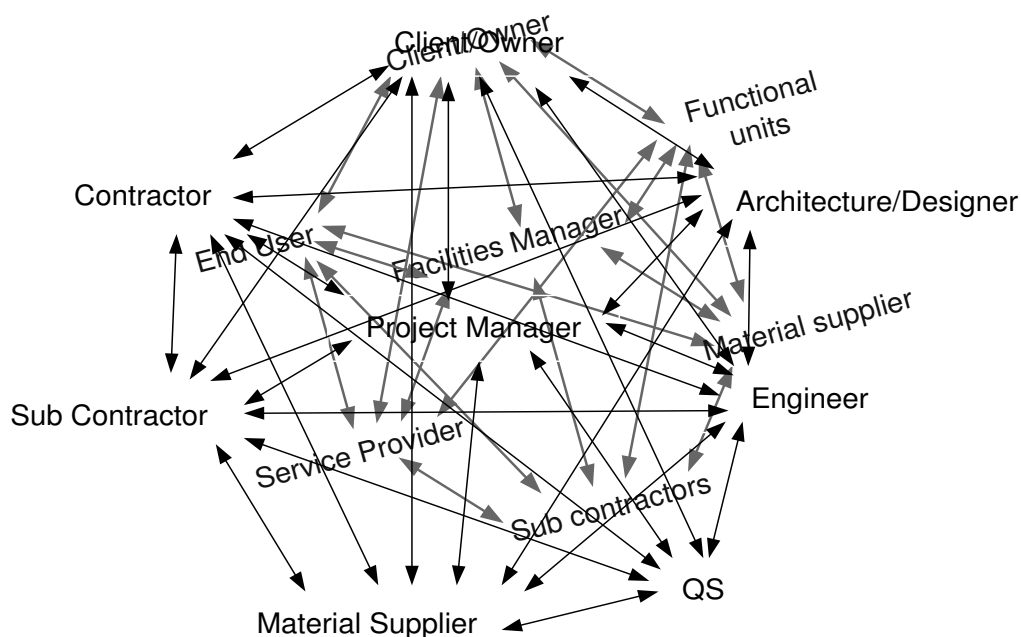


Figure 11: Collaborative network for TFM

Under such RIVANS networks, information, material, and service flow can be transferred from the PM to FM, phase in order to deliver better services to the end customer. However, paper developed a collaborative network by conducting the literature survey. Hence a gap of the interactions between stakeholders in the RIVANS needs to be discovered through a comprehensive empirical research which will be the next step in this research.

4.0 Conclusion and Recommendations

The extent of relational co-operation varies widely with the objectives of the stakeholders. A range of relationship types, such as strategic partnering and arm's length, strategic alliance, joint ventures exists in many industries. The research intention was to develop a conceptual network by integrating both supply chain networks in PM and FM

through common values. Integrating PM and FM eventually creates TFM collaborative network that represents the whole life cycle of built asset. In PM phase, stakeholders were centred to the client's project manager who acts as the broker in networks. The project manager would reinforce the interaction between various parties by eliminating weak collaborations to achieve common goals. Facilities Manager highlighted as the broker in FM phase where various stakeholders entail to accomplish the tasks of the operation and maintenance phases. The paper concluded that Facilities Manager and the Project Manager can be the key brokers of the TFM collaborative network who would link two phases with the common set of goals from the initial stage of the TFM. It was also highlighted that there are more structural holes exist in TFM network, which required to clarify through empirical analysis.

With the increased change of client perceptions and end user requirements it is essential to maintain strong ties between stakeholders who involved in both FM and PM phases. TFM network would be favourable for all stakeholders to enhance the performance of the lifecycle of the built asset.

5.0 Acknowledgement

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Managing Facilities Manager's Knowledge through Knowledge Capture, Knowledge Store and Knowledge Reuse

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Abstract

The profession of facilities management (FM) is becoming knowledge driven. In this regard, managing facilities managers' knowledge helps for a better output through the creation of supportive and cost effective physical environment that strongly supports the primary objectives of office buildings sector. This study attempts to bring in knowledge management insights into facilities management and explores strategies of managing facilities manager's knowledge. Case studies of three in-house FM teams occupied in three leading office buildings in Sri Lanka were used to approach the research problem. Data was collected using semi-structured interviews with three individuals from each case. As the study reveals knowledge capture, store and reuse process could be effectively used to manage facilities manager's knowledge, hence the effort of the study was to introduce standardized way to manage facilities manager's knowledge and it has been achieved through the literature and empirical findings. Performing complex facilities management tasks requires facilities management experts, unfortunately, there is usually a shortage of such people and their knowledge is almost always locked away in their heads. So, the challenge is to capture and automate their knowledge to make it available to others. As per case study reveals it is critical for organizations to store the knowledge, and provide access for achieving sustainable competitiveness and to move forward and deliver a better service day by day. It is critical to have a knowledge base for the further development of the FM profession. Reusing knowledge is crucial for the organization in achieving FM duties. As per the FM professionals facilities managers should use the stored knowledge in order to come up with new ideas and expertise in order to face new and challenging situations. This research is of exploratory nature which explored an emerging FM profession in Sri Lanka. Further research is required to fully understand how knowledge management concepts could be incorporated within FM professions world-wide.

Keywords: Facilities Management, Knowledge management, Sri Lanka, Office Buildings, Case studies

Background

Facilities Management (FM) is frequently described as “an integrated approach to operating, maintaining, improving and adapting the buildings and infrastructure of an organization in order to create an environment that strongly supports primary objectives of that organization” (Then, 1999, P.22). Knowledge Management (KM) is an area that represents the challenge to all organizations as a source of economic success (Puddy et al., 2008). KM is defined as the process that creates or locates knowledge and manages the dissemination and use of knowledge within and between organizations (Darroch, 2003). Managing FM knowledge is basically creation of FM knowledge by giving relevant education and opportunities to get experience and then acquiring knowledge using KM tools and disseminate through the required persons in the organization or store it and use it in the future.

FM is a multidisciplinary profession which demands various expertise knowledge and experience and it requires multi-professional involvement in achieving its functions (Nutt, 2000). Moreover, knowledge and experience demands and gathered by a facilities manager varies according to the building and infrastructure, primary objective of that organization, types of occupants, attitude of the occupants, decisions of the management and so on. FM is a highly changing profession it requires frequent updates. There are very few FM experts in developing countries like Sri Lanka who has extensive knowledge and experience in the field of FM. Above reasons such as demand of various knowledge and experience, involvement of multi professionals, variation of demanding knowledge according to facility, highly changing nature of the FM knowledge and lacking of FM experts triggers out the critical need and the importance of managing facilities manager's knowledge for the establishment and the development of the FM profession.

KM is an umbrella concept covering many aspects. This research will mainly focus on building up a KM framework to capture; store and reuse FM knowledge. Knowledge capture, store and reuse is the processes by which organizations/individual capture what has been learnt from experience and education, store it in a knowledge base and apply to their day to day operations in order to improve the quality of the deliverables, to reduce the costs and to reduce the risks (Haigh, 2005).

The rest of this paper is structured under following key topics literature findings, research methodology, research findings and finally, conclusions.

Aim

The Aim of this study is to investigate how processes of knowledge capturing, knowledge storing and knowledge reusing could be used to manage facilities manager's knowledge and to develop knowledge Management frame work to facilitate knowledge management among facilities managers within Sri Lanka

Objectives

01. To identify and study the concepts of knowledge, knowledge management, knowledge capturing, knowledge storing and knowledge reusing.
02. To investigate How knowledge capturing, knowledge storing and knowledge reusing could be used to manage facilities manager's knowledge
03. To develop a framework, to manage facilities manager's knowledge in Sri Lanka.

Key Literature Findings

It is much critical to have vast store house of FM knowledge and experience be available to each facilities manager, access to this knowledge will allow them better meets the future demands and achieve FM functions productively. Knowledge capture, store and reuse is the process by which organizations/individual capture what has been learnt from experience and education, store it in a knowledge base and apply to their day to day operations in order to improve the quality of the deliverables, to reduce the costs and to reduce the risks (Haigh, 2005).

Based on the literature findings KM in relation to the FM, a framework has been developed to manage facilities manager's knowledge by linking knowledge capture, knowledge store and knowledge reuse processes (see Figure 1).

Knowledge Capturing in Facilities Management

Effective knowledge capture is about turning personal knowledge into corporate knowledge that can be widely shared and properly applied throughout the organization in such a way as to create competitive advantage to the organization. Many FM associated firms have limited understanding and less experience in how to identify significance knowledge, capture it and promote its use through out their own organizations. As FM matures, it needs to think more for itself, to develop its own contribution to management expertise, with less reliance on borrowed concepts and imported expertise from other professional fields of activity (Nutt, 2000). Further, he states that capturing knowledge from experts who need to feed forward their specific experiences, in order to contribute to the FM knowledge base is vital to the future success of FM.

Understanding what knowledge facilities managers may need, use and create in the future is an important area for investigation for FM organizations to remain competitive (Nutt, 2000). So, in managing facilities managers knowledge first emphasis has to given to identify the key areas of FM within which the knowledge has to captured as illustrates in the conceptual framework (figure 1) those areas are FM tasks and operations, FM problems and techniques, FM ideas and concepts, FM scope and context. Capturing all FM knowledge is not worthwhile so, consideration has to be given to identify most critical knowledge that are crucial to achieve FM tasks, in order to achieve that FM knowledge has to be evaluated according to a certain criteria and filter the critical knowledge through the literature survey criteria which is been establish, and illustrates in the figure 1.

Knowledge Storing in Facilities Management

Knowledge Storing involves creating the capability for organization and retrieval of knowledge, a concept also referred to as organizational memory (Mariano and Casey, 2007). A large body of research has proposed the critical role of organizational memory (Walsh and Ungson, 1991) as a central system in the storage of knowledge produced by individuals (Kim, 1993) and organizational learning processes (Mariano and Casey, 2007). FM is challenged to build its own distinctive knowledge-base with supporting methods, techniques and data structures to underpin best practice, to advance the field, and to bridge the gap between its promise and performance (Nutt, 2000).

What knowledge has to be stored is a critical issue that should be given due consideration in building up a FM knowledge base. The criteria to determine what knowledge to store are: knowledge that help creating new knowledge,

knowledge that address key and frequent issues of FM, knowledge which supports FM further development. How to store is another critical issue that should be addressed in developing an expert system to store facilities manager's knowledge (see Figure 1). Black (1987) identified five major steps in storing knowledge in to the expert system (see Figure 1) those are knowledge representation: this simply focuses the dialog between the developer and expert, it finds methods how to represent expert's knowledge in a logical way, analysis and design of knowledge base: this step focuses on analyzing the data that has been represented according to the analyzed data designing of the knowledge base has to be done, normalization: this step is concerned with removing redundancy in the underlying data model, it improves the performance and efficiency of the knowledge base, entity relationship analysis: after normalizing, it is possible to infer relationship by sharing of attributes, further analysis can be carried out in to the qualities of the relationship.

Knowledge Reusing in Facilities Management

Nonaka and Takeuchi (1995) define knowledge reuse as adaptation of explicit knowledge of successful practices so as to generate new and useful ideas. According to Markus (2001), reusing knowledge involves both recall (that information has been stored, in what location, under what index or classification scheme) and recognition (that the information meets the users' needs, as well as actually applying the knowledge).

Knowledge reuses within organizations are typically performed for two distinct objectives (see figure 1), those are knowledge reuse for replication and knowledge reuse for innovation, knowledge reuse for replication focuses on knowledge acquisition through which best practices are transferred (replicated) in order to increase productivity, knowledge reuse for innovation focuses on knowledge integration through which other's knowledge are adapted (integrated) into one's existing knowledge stock in order to accomplish an innovative task (Majchrzak *et al* 2004). Building of framework to manage FM knowledge focuses on achieving both objectives. According to Nutt (2000) the areas where FM knowledge reuse will give its highest contribution are managing facility operations and support services, managing facility use and performance, managing facility procurement and adaptation (see figure 1).

Reusing FM knowledge will again create new knowledge and new practices, that knowledge and practices may be more valuable than existing ones hence, those are the pure and new knowledge coming from individuals/organizations by making use of the existing knowledge. Due to that reason FM knowledge reusing will contribute a lot to the further development of the FM profession. The main areas that it requires further attention in its development process are (see figure 1) new strategic directions: exploring the changing priorities, potential scope, future functions and impact of FM, Future performance imperatives: developing the basis for the next generation of property and facility performance criteria, management methods, operational procedures and decision techniques, Policy and investment development: investigating the key property and FM issues for the future and the development of radically new approaches to investment and risk. It requires attention further to following areas: produce documentation of advanced FM practice experience, cross-sector benchmarking criteria, forecasting key future FM issues and possible solutions, clarify the distinctive features of the facilities management, clearly defining the unique FM functions, develop management concepts and expertise in these unique areas, adapt and apply relevant management concepts and proven technical expertise that can be modified to directly support key areas of FM (Nutt, 2000), consideration must be also given to capture that new knowledge and update it to the FM knowledge base.

Framework

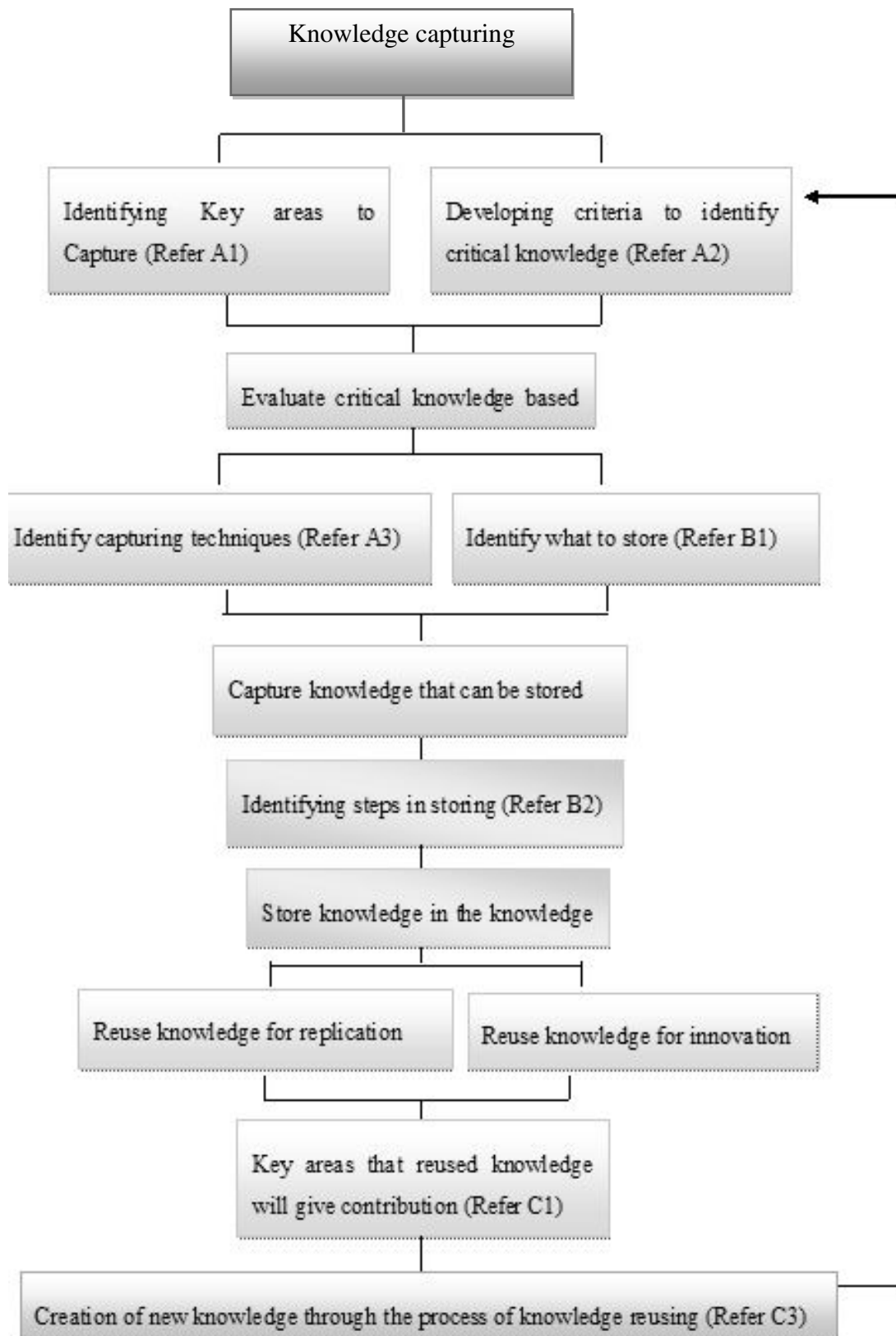


Figure 1: Conceptual framework to manage facilities manager’s knowledge

<p>A: KNOWLEDGE CAPTURING</p> <p>A1: FM knowledge areas to capture</p> <ul style="list-style-type: none"> ● FM tasks and operations. ● FM problems and techniques. ● FM ideas and concepts. ● FM scope and context. <p>A2: Criteria for identifying Critical knowledge</p> <ul style="list-style-type: none"> ● Contribution, to the core business of an organization; ● Support, to business operations and productivity; ● Effectiveness, through its own facilities management arrangements; ● Contribution, to the delivery and quality of out-sourced, part-sourced and in-sourced services ● Satisfaction, provides to the end-user/ employee ● Quality, service received by the customer/consumer. 	<p>B: KNOWLEDGE STORING</p> <p>B1:What to store</p> <ul style="list-style-type: none"> ● Knowledge that help creating new knowledge ● Knowledge that address key and frequent issues of FM ● Knowledge which supports FM further development <p>B2: Steps in knowledge storing</p> <ul style="list-style-type: none"> ● Knowledge Representation ● Analysis and designing of the knowledge base ● Normalization ● Entity relationship analysis.
<p>A3: Techniques for capturing</p> <ul style="list-style-type: none"> ● Interviews ● Observation ● Induction ● Laddering ● Concept Mapping ● Constrain tasks ● Concept sorting 	<p>C: KNOWLEDGE REUSING</p> <p>C1:Key areas that give contribution</p> <ul style="list-style-type: none"> ● Facility operations and support services ● Managing facility use and performance ● Managing facility procurement and adaptation <p>C2:Creation of new Knowledge</p> <ul style="list-style-type: none"> ● New strategic directions ● Future performance imperatives ● Policy and investment development ● Clarify the distinctive features of the facilities management, ● Clearly defining the unique FM functions, ● Modify and support key areas of FM practice

Research Methodology

Building up a KM framework to manage facilities knowledge need in depth and continues investigation in real life context. In addition it needs to access FM professionals, who could explain their views, importance, triggers, mechanisms and other organizational key parameters attributed to KM. In order to achieve above mention requirements qualitative research approach has been adopted. Among the numerous approaches available in the qualitative approach, case study has been selected for this research. Semi structured interviews has been used as the

main data collection tool in this research. Unit of analysis or the case in this research is FM related organizations. Three Sri Lankan leading FM related organization where key FM professionals are involved in ensuring occupants' comfort ability has been selected as three cases and within one organization three FM professionals who have extensive knowledge on FM functions have been interviewed. The description of cases and professionals interviewed has been stated below.

Case A

With over 750,000 square feet of prime office and retail space, this organization is an international business complex on par with premium grade buildings in major cities around the world. Built to the highest standards, this impressive landmark comprises two 39 storey towers connected by a 4 storey retail block. It has attracted prestigious local, international and multinational companies as tenants, making it the most sought after business address in Sri Lanka. With its prime location in the heart of the city in the Central Business District (CBD) and easy access to all main banks, major five star hotels, government offices, shops and the headquarters of some of the largest businesses, this towering business complex is Sri Lanka's tallest and most impressive commercial landmark. Within this organization three prominent FM professionals have been interviewed who have many years of experience in the field of FM namely facilities manager, assistant facilities manager and electronic engineer.

Case B

This organization is a largest banking and financial services organization. It has more than 32,000 skilled professionals operating out of 15 Group Service Centers present in five countries in Asia, including India, China, Malaysia, Philippines, and Sri Lanka. Data has been collected from three prominent facilities managers in this organization, who have extensive knowledge and experience in the field of facilities management namely facilities manager, assistant facilities manager, outsourced facilities manager.

Case C

This organization is one of the leading government banks in Sri Lanka. This building is a 32 storied head office building with a total built up area of 600,000sq.ft. was constructed in 1987 to house all administrative offices, International Division and Corporate Branch of the bank. Managing this building is done with the involvement of well qualified and experienced FM related professionals. So, data has been collected from three key FM related professionals namely maintenance manager, human resource manager, electrical and plumbing engineer.

Research Findings

Knowledge in the context of Facilities Management

As per the respondents in case A, Knowledge is a largely contributing factor in organizations' value creation. The importance of knowledge in the organisational context was also highlighted by the case B respondents as per them, In today's knowledge economy, knowledge is increasingly being considered as an asset that needs to be effectively managed to create added wealth. It was supported by case C respondents, as they mention knowledge has been recognized as the most important aspect in human life. Organizations' competitive advantage depends more than anything on its knowledge.

Knowledge Management in the context of Facilities Management

As mentioned by case A respondents, KM is about management of information, knowledge and experience available to an organization. Knowledge management can be taken as an essential procedure to gather competitive advantage and it was further supported by case B respondents as they mention KM is about encouraging individuals to communicate their knowledge by creating environments and systems throughout the company. As per the case C, respondents, knowledge is a valuable asset that must be managed and the essence of knowledge management is to provide strategies to get the right knowledge to the right people at right time and in the right format. So, managing such knowledge is important for any organization.

Informal Knowledge Management practices adopted in FM organizations

As per case A respondents, In the FM department they prepare policies and procedures and operation manuals and keep day to day records and make the FM expertise explicit. As Case B respondent's states, basically they operate

functional instructional manual in FM department and frequently update it. Furthermore, normal practise of case C respondents is preparing internal policies and procedures and daily reports and practising complaints management system and request management system which can also state under the practices of knowledge management

Knowledge Capturing, Knowledge Storing and Knowledge Reusing

According to respondent in case study B, the most effective way of implementing knowledge capture, knowledge store and knowledge reuse process is conducting a **brain storming session** where all the FM experts are get together in to a **common forum**, make them **talk about every aspect of FM** and all forum should be recorded and noted down after that, only the best practices should be sorted among the knowledge that they have demonstrated by experts. After that all the knowledge should **taken down to a common structure make codes and references**, well **documented using latest software** and should **get the critics** from the experts. It is also important to make available **stored knowledge to all the percent and future facilities managers** and to **update it time to time and controlling versions**. However, According to the facts revealed by case C respondents, method of capture, store and reuse knowledge includes the steps of **collecting knowledge information** from information-source terminals **via a network**, the knowledge information including information regarding research and development, problems, and solutions of the problems, **storing the collected knowledge information in libraries** by classifying the collected knowledge information based on a type and an attribute of the collected knowledge information, **organizing the stored knowledge** information based on importance and frequency of use thereof, and **retrieving the standardized knowledge information from a library in response to a retrieval request** so as to provide the retrieved information for a requesting party which made the retrieval request.

Knowledge capturing in the context of Facilities Management

Respondent in case study C states that “*Performing complex tasks requires the know-how of the organization's experts and specialists*”, unfortunately, there is usually a **shortage of such people and their knowledge is almost always locked away in their heads**. If they leave the organization, they take their knowledge with them. So, **the challenge is to capture and automate their knowledge to make it available to others**. According to respondent in case study A “*knowledge capture is all about getting experts knowledge out to some extent*”, but however **all the knowledge cannot be capture it resides in the human mind and could not be taken out**. According to them only the basic knowledge can be captured, knowledge is unique to person to person so that the knowledge is very hard to capture however once captured and recorded it will **Enhance human decision making by offering advice, Free experts from repetitive routine decisions for more productive and rewarding work, Ensure that decisions are made in a consistent way and as speedily as possible, Retain the organization's expertise in a readily maintainable form**. Respondents in case study B states that critical knowledge that has to be taken from the experts is best practices this can be also called as **benchmarking successful practice**. Many techniques are available to capture knowledge however in the view of most respondents the **best two methods to capture knowledge are interviews and observations**. As per the respondents in case C, Organizations today are making every effort to improve their products and services while controlling costs, many have undertaken Business Process Re-engineering (BPR) to find better ways to perform complex tasks, or to improve and automate their operations, Performing complex tasks requires the know-how of the organization's experts and specialists.

Critical knowledge areas that should be captured from FM professionals have been discovered through the empirical study and illustrates in the figure 2

Techniques of knowledge capture

As per the case B respondents, experts should give the freedom to talk about his experience by doing so best practices can be easily captured. Case C respondents hold a different perspective on this regard as per them, observation is the best method to capture knowledge rather than any other methods and it will contribute to the success of managing knowledge of FM profession.

Knowledge Storing in the context of Facilities Management

According to the respondent in case study B, “it is critical for organizations to store the knowledge, and provide access to it”, in a professional and efficient manner throughout the organization for leveraging it for achieving sustainable competitiveness. Respondent in case study A supports this further by stating ignorance in knowledge storing might be very costly in the future; they might lose an edge over the organizations. Further identified facts in case A, reveals that knowledge storing is important for organizations to move forward and deliver a better service day by day. As per the

respondents in case A, it is critical for organizations to store the knowledge, and provide access to it, in a professional and efficient manner throughout the organization for leveraging it for achieving sustainable competitiveness.

Explicit forms of knowledge storing have been identified through the case study survey and illustrates in the following table.

Table 7: Explicit forms of knowledge storing

CASE	Forms of knowledge storing
B	<ul style="list-style-type: none"> ▪ Electronically ▪ data bases ▪ documentary films ▪ intranet ▪ hard drives ▪ email folders ▪ personal laptops ▪ on paper ▪ documents ▪ project files
C	<ul style="list-style-type: none"> ▪ Client presentations ▪ Competitor intelligence ▪ Customer data ▪ Marketing materials ▪ Meeting minutes ▪ Policy documents ▪ Price lists ▪ Product Specifications ▪ Project proposals ▪ Research reports ▪ Training packs ▪ Policies and procedures ▪ Intranet

Knowledge base

FM is challenged to build its own distinctive knowledge-base with supporting methods, techniques and data structures to underpin best practice, to advance the field, and to bridge the gap between its promise and performance, most of the respondents agrees with the above statement, respondent in case study A states “ *it is **critical to have a knowledge base for the further development of the FM profession***”, hence having a knowledge base will **provide easy means of accessing experts knowledge** for the **novel facilities managers** as a central system in the storage of knowledge produced by individuals. What knowledge has to be stored is another critical issue that should be given due consideration in building up a FM knowledge base, According to the respondents in case study A, “ *however, entire knowledge cannot be stored, there are certain knowledge that are unique to a person and will die down with the person*”. Hence, the knowledge that should be store is the **knowledge that could act as basis or for standards for the decision making of a facilities manager**. According to respondent in case study B, when storing knowledge always have to pay the attention to **store the facilities management best practice** because those are the knowledge that will contribute to the success of the FM profession.

According to respondents in case A, interest for KM grown rapidly with the development of information technology (IT). Accordingly, FM Knowledge base will require carefully prepared, structured management information systems (MIS) in which information is recorded, stored and made available to those who need it. Furthermore as mentioned by case C respondents, it is needed to have computer software to control the knowledge database, and that will guide users in finding, at any given time, information that will serve their personal development and work needs. FM knowledge base may has to deals with several issues in the means of storing and distributing knowledge, technology can assist to alleviate these issues and can provide easy ways to store and distribute knowledge.

Expert System

As per the respondents in case A, FM expertise is dispersed among several individuals while a single expert may be difficult to locate, let alone interview. Meanwhile, the knowledge management must still resolve the problem of limited availability of experts in disciplines where the expert is unique or indispensable and cannot be spared from the day-to-day task. Respondents in case C hold the perspective that, Artificial intelligence will develop knowledge-based systems for problems in which the constant involvement of human experts is critical; achieving FM duties requires constant involvement of a human expert, so it is worthwhile to have a KBS for the FM profession. However, the very scarcity of the FM experts will be the motivation for system development

Criteria for Knowledge Storing

As per the respondents in case A, entire knowledge cannot be stored, there are certain knowledge that are unique to a person and will die down with the person”, as an example the ability or skills to face and adopt to critical situations, those kind of knowledge cannot be stored, hence the knowledge that should be store are the knowledge that could act as basis or for standards for the decision making of a facilities manager, facilities managers may have to take the different decisions, in different times for a same situation so when making decisions based on a criteria the quality and accuracy of the decisions will be increased so when considering what to store, emphasis has to given to store that kind of a criteria which would contribute in decision making of a facilities manager. As per the respondents given by case B respondents, when storing knowledge always have to pay the attention to store the facilities management best practices.

Knowledge Reusing in the context of Facilities Management

Respondents C holds the opinion that “*reusing knowledge about what was done, how and why things are or were done, what things mean, and how this knowledge can be applied in other settings is crucial for the organization success*”. In the view of respondent in case study A “*FM organizations have knowledge- intensive working environments, so it requires, relevant knowledge **to find flexible solutions and solve problems under tight deadlines**, achieving FM duties successfully are mainly based on occupant’s needs and the individual facilities managers’ knowledge and expertise*”. Therefore storing those expertise and make other employees use this expertise is crucial to be success in achieving FM functions.

Respondent in case study B states that “*many organizations have **implemented knowledge management systems to promote knowledge reusing***”, success of a KMS is contingent not only on knowledge contribution but also on how well (or often) such knowledge is used or applied for the benefit of the organization.

Finally framework has been adopted to capture, store and reuse of FM knowledge by revising conceptual frame work according to the research findings.

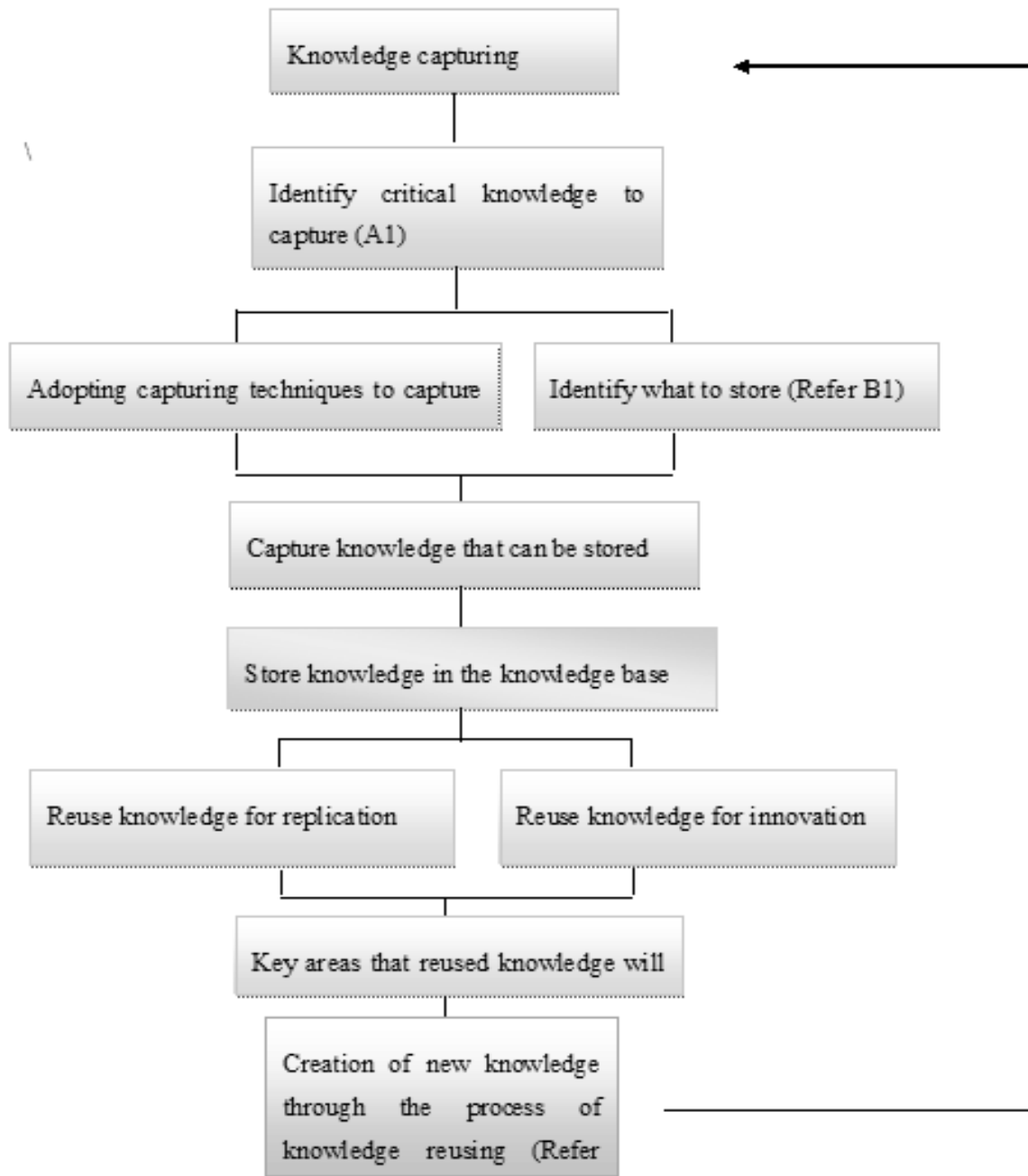


Figure 2: Framework to manage facilities manager's knowledge

<p>A: Knowledge capture</p> <p>A1: Critical knowledge areas to capture</p> <ul style="list-style-type: none"> ✓ Property management • Strategic property management • Property acquisition • Risk management • Lease management ✓ Plan for renovation and new facilities • Strategic facilities planning • Building design construction, • Energy management ✓ Operation and maintenance of facilities • Facility maintenance • Condition assessment ✓ Knowledge that is required to support infrastructure ✓ Knowledge on corporate objectives ✓ Knowledge on managing people ✓ Knowledge on required support services ✓ Knowledge on management practices ✓ Knowledge on financial Management, Communication skills, Interpersonal skills, Human skills, Business skills. <p>A2: Techniques for capturing</p> <p>Interviews, Observation</p>	<p>B: Knowledge store</p> <p>B1: What to store</p> <ul style="list-style-type: none"> • Facilities management best practices • Knowledge that contribute in decision making of a facilities manager <hr/> <p>C: Knowledge reusing</p> <p>C1: Key areas that give contribution</p> <ul style="list-style-type: none"> • Facility operations and support services • Managing facility use and performance • Managing facility procurement and adaptation <p>C2: Creation of new Knowledge</p> <ul style="list-style-type: none"> • New strategic directions • Future performance imperatives • Policy and investment development • Clarify the distinctive features of the facilities management, • Clearly defining the unique FM functions, • Modify and support key areas of FM practice
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Conclusion

In considering knowledge capturing, knowledge storing and knowledge reusing, processes, empirical study reveal that most effective way of implementing these process are conducting brain storming sessions, collecting knowledge via a network, storing in libraries and retrieving in response to a retrieval request. As per the research findings performing

complex facilities management tasks requires facilities management experts unfortunately, there is usually a shortage of such people and their knowledge is almost always locked away in their heads. So, the challenge is to capture and automate their knowledge to make it available to others in doing so it is effective to capture best practices. As per case study reveals it is critical for organizations to store the knowledge, and provide access for achieving sustainable competitiveness and to move forward and deliver a better service day by day, knowledge can be store electronically or in paper. Furthermore, according to the case study participants it is critical to have a knowledge base for the further development of the FM profession. Through the research findings it could be concluded that, reusing knowledge is crucial for the organization achieving FM duties. Further as per the FM professionals facilities managers should use the stored knowledge in order come up with new ideas and expertise in order to face new and challenging situations.

As the study reveals knowledge capture, store and reuse process could be effectively used to manage facilities manager's knowledge, hence the effort of the study was to introduce standardized way to manage facilities manager's knowledge and it has been achieved through the literature and empirical findings.

As far as the FM professionals concern, they have limited understanding and less experience on KM aspects, Thus, it is recommended to facilitate KM workshops, and training programs for the FM professionals, in order to make them knowledgeable of KM aspects and easy means of adopting them to FM organizations. Very little KM practices have been adopted in the field of FM. It has been identified through the research findings. So, emphasis has to be given to facilitate brain storming sessions, common forum and to capture FM knowledge and it must be ensure to take those sessions regularly and also it is recommended to create a intranet or common network which every facilities manager can log in and update their knowledge and use the knowledge stored in that network and which also facilitates real time communication. In the organizational level it is recommended to form a KM team, consist with people who possess with relevant knowledge and skills, where this team will capture FM knowledge effectively from FM experts in the organization, and will store them in a most appropriated manner and will facilitate reusing in most outstanding ways.

In knowledge capturing, sometime experts are not willing to give their knowledge because they think that it will create a threat to their job, hence the person who capture knowledge should be capable of convincing them to contribute his/her knowledge and it is recommended to conduct awareness programs for the FM experts introducing criticality of capturing FM knowledge for the future growth and the establishment of the FM profession. In knowledge storing and reusing, technology is an issue that should be dealt with, in most of the cases FM professionals do not possess with IT knowledge that is required for the knowledge storing process, so effective knowledge storing process cannot be implemented, so it is recommended conduct workshops to give required technical exposure to the FM professionals in order to implement effective knowledge storing process. This study can be made applicable in international context in managing facilities manager's knowledge by doing few adjustments to suit to the country's business environment.

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Issues in small sector housing construction in Sri Lanka: case of services installation

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Abstract

Building a house is a life time venture and a dream of many individuals. However, constructing a house is a complicated process which involves interpreting various ideas and collection of number of people's effort. In such away, building services carry a significant role and efficient services installation leads to a long life of any building types. Moreover, cost of services installation represents considerable amount from the total project cost. It is notable, improper installation of services lead to an increased cost of maintenance and repair cost while dissatisfying the user. This is the common issue seen in the small sector housing construction. Therefore, the aim of this paper is to address "common issues in small sector housing construction in case of services installation". Apart from that the study analyses the informal and formal sector involvement in the housing construction. The structured questionnaire survey was carried out with house owners. The survey results analyzed using SPSS software. Electrical and plumbing are more demanding services and mechanical systems were received less demand in the small sector houses. The survey results show electrical problems are being the worst followed by plumbing and mechanical problems. Trip switch failure, power leakage and damages to equipment due to excessive power are some common dilemmas faced by the house owners regarding the electrical system. Water leakage and water seepage through walls are common issues with in the plumbing system. The study was enable to identify informal sector and formal sector involvement in installation of services in small sector housing construction as 87.64% and 12.36% respectively. Further, the suggestions and recommendations were made in order to overcome the identified issues in case of services insatalltion in small sector housing construction in Sri Lanka addresses in the paper.

Keywords: *Issues, housing construction, services installation*

1.0 Introduction

Construction is a large and complex industry comprising many types and sizes of organizations and a diverse range of professional and other representative bodies (Cook and Williams, 2014). In Sri Lanka, construction industry contributes more than 8 % to the GDP (Central Bank, 2012). In which housing construction gives a greater support to GDP as well. The demand of houses in the Colombo metropolitan region increased with continuing population growth and economic development. Building a house is a life time venture for most people. The demand for housing for sale or lease at market prices is extremely limited (Armstrong, 2002). According to Milanovich (2006), majority of new houses are constructed from saving money, or getting bank loans, or some other means. Nowadays, the trend of willing to build a own house is become a fashion and a dream of many individuals. As stated by Milanovich (2006) , in Sri Lanka housing problem is very acute, particularly among the poor and other marginalized categories. If the construction sector is concerned, client, consultant and contractor are the direct stakeholders involved in the construction process to get the project output in a successful manner. However, compared to the general practice, contactor's involvement with the client is very strong in a small sector housing construction (Mlinga and Lema , 1999). Meanwhile the clients give more opportunities for the informal sector rather than formal sector to do the contracts. Thereby, the consultants' role is hidden in small sector construction projects (Mitullah and Wachira, 2003). According to Chana (1981 cited Wells, 2007), the informal construction groups provide almost all the construction in the rural areas of developing countries and 50% of housing in the urban areas. Informal labour contribution to the construction industry in Sri Lanka is about 75% from the total labour usage for whole construction industry and that is a huge proportion. Among those, most of the informal workers are depending on housing construction (Jayawardena and Gunawardena, 1998). Further stated that low level of education, training and skills and poor level of workmanships are some issues with the labourforce in Sri Lankan construction Industry. When considering the small sector housing construction, there are many problems arise especially in the services installation. Building services carry a large risk aspect on many projects – they are known to have the largest profit margin within the construction process, and form on average 30-40% of the total project value, but may conversely be the biggest loss leader (Mawdesley, 2008). Thus, proper installation of services becomes vital for a sustainable building.

The design of building services traditionally suffer due to a lack of information about the system. Installation is also often unplanned, thus adding further complications (Trrey and Surgener, 2004). The knowledge about understanding building services system applicable to residential spaces, reading the drawings, and applications of elements are the essential requirements of the builders of services installation (Wild, 1997). This is being more crucial with the involvement of informal sectors in housing construction. With the demand of constructing houses, still most of the clients are relying on informal sector believing it is more economical than the consulting workers from the formal sector. However, as depicted in the literature, during the construction and operation period clients are facing more difficulties especially regarding the services installation. Therefore, the aim of this research is to identify the common problems related to services installation in small sector housing construction in Sri Lanka. In order to achieve that aim, the following objectives were formulated.

- To investigate the problems in small sector housing construction projects in terms of services installation
- To recommend good practices, and strategies that could be adopted to strengthen and develop informal contractors in services installation

This research was limited to the residential buildings up to three stories and age of the house was greater than five years.

2.0 Literature Review

According to the Arabic dictionary Al-Munjid (Al-Balabki, 1987), a house means a place to settle down, relax, become calm, calm down, reside in a place. In the modern day's context, housing development is seen as a key issue to be addressed in the socio-economic and political agenda across the world, particularly in the developing countries where urban housing poses a challenge in the process of development (Jayasena et al., 2006). The design and construction of building services traditionally suffer due to a lack of information about the system. It is not deemed necessary to provide the building services engineer with an upfront design. Installation is also often unplanned, thus adding further complications (International Housing, 1999; Surgener, 2004). The housing construction sector is unique in its nature and projects are different from each other. According to Terry and Surgener (2004), over the course of several years and hundreds of new home inspections, never inspected a home with less than worth of \$600 in defects.

In 'traditionally' procured construction projects, building services and structural design are not integrated (Hinks, 2005). As stated by Mawdesley (2005), in the most cases construction is well under way before any thought is given to the building services design although the design and construction of mechanical, electrical and plumbing services are generally overlapping processes. Thus, often many practical issues associated with building services, including too many visits by too many trades. This leads to greater health and safety risks, and questions over maintenance and access issues. Building services are not considered at the front-end of the project, thus resulting in work hastily being completed in difficult conditions, and it could be seen services distribution and installation are often unplanned processes in the reality. Wijayamali et al. (2014) identified that quality aspects is common issue with the services provided. In addition, another critical issue is fragmented of the construction team. This leads to dissatisfaction in performance of the building function. According to Brankovic (2003), the biggest obstacle to improving on this process is a lack of knowledge and skill transfer from project to project. Individuals often learn 'on-the-job'. Once the task is completed they move on to another job. However, more effective learning process always leads to the perceived 'ideal' route which is currently underpracticed by the workers in the informal sector.

Mawdesley (2005) pointed out that there are many factors in building services construction which are uncertain. For example, design, manufacture and installation time, overall project duration, resource demands, potential errors involved in traditional and prefabricated installation of services distribution, training requirements, and cost. These uncertainties present risk to members of the project team. Since risk is present, it must be controlled. As Connolly and Leiper (2005) stated, construction and installation of services system is major part and do at last. Another important fact highlighted is, the space within which the services installed is restricted, and often cramped with more than one trade completing its part of the works. Due to lack of full design and layout information, it is unclear about what occurs within the service voids, and impact on the quality of the final outcome.

Building surveying reports are recording more than one hundred common issues in terms of services problems, structural problems, designing problems, repair and maintenance problems, in buildings (Glover, 2006). The purpose is giving some warning in relation to a future repairing liability or affecting the value of the property and what kind of actions or precautions need to be taken by the building owners. These lists are not intended to be exhaustive but should be of interest (Glover, 2006). The common problems regarding services are listed as follows.

- Leakage from poorly designed shower enclosures
- Defective drains
- Lead plumbing
- Sub-standard electrical installations
- Failure of damp-proof courses
- Leakage of water into wall cavities from concrete ‘Finlock’ gutters
- Lack of party/fire walls in old terraced roof spaces
- Leaking parapet and valley gutters
- Lack of party/fire walls in old terraced roof spaces
- Leaking gutters and down pipes
- Shortage of power sockets
- Poor septic tank and cess pit drainage arrangements
- Damp penetration and staining to walls from leaking overflow pipes
- Corrosions in steel water tanks

3.0 Research Methodology

Comprehensive literature survey was done to identify the problems related to services installation in small sector housing construction and its generation during the construction process. First unstructured interviews were carried out with suitable persons who have greater knowledge in the area of housing construction to identify the related issues of the subject area and to improve the directions of the research as a preliminary survey. Then, structured questionnaire survey was carried out to identify mostly encountered problems related to services installation and to formulate solutions for mitigating the problems in services installation related to housing constructions. The questionnaires were distributed among the house owners with the sample of 45 houses in Moratuwa region.

4.0 Research Findings

4.1 Problems in services installation

It was revealed that around 42% of the houses were constructed with less provisions in services integration at the initial stage. Later on as time dictates and as need arises it was planned to expand the number of rooms, bathroom, and other amenities which in turn requisite the need of new types of services integration according to the requirement. It was identified that the problems regarding Electrical services is being the most significant issue, statistically it is around 90%. Plumbing problems were identified as the second leading problem, statistically proved as 65% and the Mechanical problems were identified as the least types of problem and it contributes around only 20% among all aspects while its integration had been reported at a very low level in small sector housing construction. According to the questionnaire survey, it was identified that electrical problems are being the worst followed by plumbing and mechanical problems. Figure 4.1 graphically shows the percentages for problems in each service according to the house owner’s perspective.

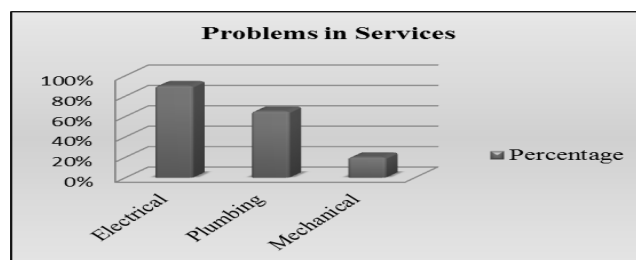


Figure 4.1: Problems in Services Installation

Mechanical systems are very hard to find in the small sector houses. However, air conditioning was the most commonly used systems while communication and security systems were also available in few houses.

During the literature and preliminary survey it was identified 10 common issues with electrical systems, 17 issues with plumbing systems and 4 issues with mechanical systems. Table 4.1, 4.2 and 4.3 summarise the findings, as per the owners’ experience. Electrical problems were analyzed according to the collected data.

Table 4.1: Ranking of problems with electrical systems

Item	Electrical Problems	Rank	Agreed %	Disagreed %
E.1)	Current leakage (during the rainy season)	2	74.33%	25.67%
E.2)	Current shorts	6	63.45%	36.55%
E.3)	Power cuts occurrence	7	60.44%	39.56%
E.4)	Trip switch (on/off) problem	1	78.34%	21.66%
E.5)	Main distribution board failure	9	25.00%	75.00%
E.6)	Switches don't work properly	5	65.98%	34.02%
E.7)	Fuse failure	8	56.80%	43.20%
E.8)	Damages occurred to electrical equipments (excessive current)	3	73.56%	26.44%
E.9)	Earth wiring problems	10	24.88%	75.12%
E.10)	Insufficiency of fittings location (out lets)	4	72.56%	27.44%

It was found that more than 78% respondents agreed that trip switch failures was the common issue faced with electrical system. More than 70 % respondents viewed that current leakages during the raining season, damages to the electrical equipments due to excessive current load, and insufficient outlets were other major issues faced by them. It is clear that one of the reasons for E8 (damages occurred to electrical equipments) may be E10 (insufficiency of fittings location-outlets) . As stated by many respondents, most of the houses were constructed without considering the future aspects. People constructed houses according to their present requirement on those days. That is why all most all the housing owners were paying their favor to expand the existing electrical system. Poor workability of switches in the fifth position and which was occurred in most of the houses as well. Generally the buttons (gang) were not properly functioning. Moreover, problem regarding current short or short circuiting was identified in sixth place. This event was caused several problems in electrical equipment and exaggerated the peoples' life. Main distribution board failures and earth wiring issues are rarely occurred. Significant failures in electricity generally lead to a huge loss in houses which includes damages to the equipment, entire structure of the whole house, or even loss of lives. Therefore, it is critical to have a more secured electrical system. Another point revealed that owners were using two different current lines. Main reason was to get separate current bills for each floor and most of the houses are rented by the third party.

Table 4.2 : Ranking of problems with plumbing systems

Item	Plumbing Problems	Rank	Agreed %	Disagreed %
P.1)	Water leakage	1	89.54%	10.46%
P.2)	Low water flow rate	12	54.66%	45.34%
P.3)	Water seepage through walls	2	82.13%	17.87%
P.4)	Water seepage through slab	5	76.43%	23.57%
P.5)	Blocks in pipes	15	25.00%	75.00%
P.6)	Cracks in pipes	9	65.98%	34.02%
P.7)	Failures in gutter arrangements	6	73.44%	26.56%
P.8)	Problems in stop valve	8	66.00%	34.00%
P.9)	Problems in check valve	16	24.88%	75.12%
P.10)	Failures in water closet	4	76.56%	23.44%
P.11)	Overflow in toilet pit (rainy season)	3	80.00%	20.00%
P.12)	Excessive air struck in water motor	11	64.33%	35.67%
P.13)	Foot valve failure	13	42.75%	57.25%
P.14)	Problems in taps ,showers workability	14	36.84%	63.16%
P.15)	Failures in showers	17	24.65%	75.35%
P.16)	Failures in Taps	7	71.33%	28.67%
P.17)	Insufficiency of gully points	10	65.00%	35.00%

Table 4.2 illustrates the plumbing problems with the relevant priority order by comparing the agreed percentage of the individual house owners. Among those problems, water leakage was identified as the most significant problem. It represented 89.54%. Water seepage through walls is in the second place and it was taken a figure statistically 82.13%. All most all the houses had these problems. These events caused several defects in wall finishes such as blistering, cracking, spalling etc. For this aspect they were spending a certain amount of money in carrying out repair works. Overflow in toilet pit was identified as the third problem. This event was mainly happening during the rainy season and could be observed in some houses which were constructed ten years ago. This issue was very rarely happening in newly built houses. The fourth problem was identified as Failures in Water closets. Failures means in case of cracks in water closet, damages in bidet sprayers, float ball, and tank lever were being the other common issues. A failure in gutter arrangement was in the sixth place. By this problem the valance boards, valleys were affected to a certain extent.

From this survey it was denoted that few of the house members were using hot water. Some of the people do not have a proper knowledge in handling the plumbing equipment perfectly; some of them do not know how to do even smaller repair works by themselves. In such instances house owners were seeking the help of a plumber. 67% of the people agreed that they were facing many plumbing issues during the rainy season rather than dry season.

Table 4.3: Ranking of problems with mechanical systems

Item	Mechanical Problems	Rank	Agreed %	Disagree %
M.1)	Air condition failure	1	33.23%	66.77%
M.2)	Security system failure	3	3.45%	96.55%
M.3)	Fire fighting equipment failure	4	2.30%	97.70%
M.4)	Errors in data communication system	2	30.23%	69.77%

Table 4.3 summarizes the problems with mechanical systems. It was identified at the beginning of the survey, rarely used mechanical systems by the selected sample. Mechanical problems were classified as the least level when comparing with whole services as this survey was targeted on small sector housing scale. It is apparent that the usability of mechanical services was in the lowest level in small scale houses. The survey results shows that problems regarding Air conditioning units failure was identified as the leading issue such as water leakage and corrosion in the outdoor unit. It was identified, in ceratin situations the house owners forget to close the door and windows when A/C was operating. It leads to increase the open space level. This would accrue more current to cool the particular area. Further , the respondents said that they do not maintenance work regularulary for A/C , if somthing wrong with the unit consult person to check the system.

The second most important problem was errors in data communication system. Security system failure was categorized as the third important failure. This problem was also able to occur due to the poor knowledge among the users. And the fourth problem was identified as failure of fire fighting equipments. In a few houses fire extinguishers were found which were expired as they were not used frequently and lack of inspection.

4.2. Parties involvement in services installation in small sector housing

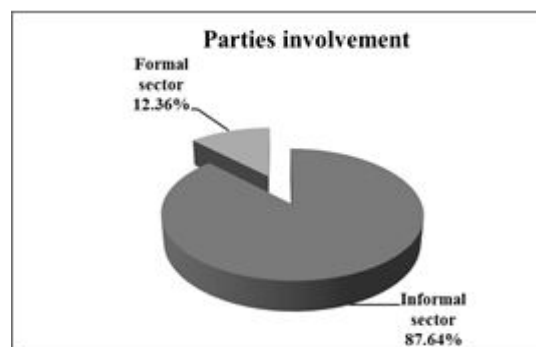


Figure 4.2 : Formal and informal sector involvement

It is clear that the problems regarding the services is very acute through the above findings and as it was reflected necessary to identify the causes of the problems. Further, during the survey the respondents were asked to interpret the parties who involved for the services work. In this survey 45 houses were identified as the sample. Out of these, 39 houses placed under the informal sector involvement and 6 houses placed under the formal sector involvement. Figure 4.2 illustrates the involvement of formal and informal sector. As per the respondents, informal sector involvement is 87.64% during the services installation. This is considerably high figure.

Many scholars mentioned that some basic characteristics of the informal sector. Wells (2007) pointed out that informal sector workers are employed in casual basis without any regular contracts and social protection. According to Koushki et al., (2005), time delay, cost overruns, low quality, financial constraints, and lack of construction knowledge are some issues in the informal sector contracts. Further, during the survey, the respondents were asked to give reasons on consulting informal workers for the services work. The respondents mentioned that main reasons for consult informal sector as believing that less cost spend compared to the formal sector although heard formal sector workers perform better than the informal sector workers. Moreover, it was revealed that many house owners are less awareness and experience with services installation. Therefore, it is very difficult to choose proper workers, materials, and hard to inspect the works during the installation time.

It is clear that most of the services installations were done by the informal sectors in small sector housing construction. A total of 10 possible limitation factors were identified from literature and preliminary survey with the informal sector workers. During the survey, the respondents were able to give their opinion and the results were summarised in Table 4.4.

Table 4.4: Limitations of informal sector

Item	Limitations	Rank	Agreed %	Disagreed %
L.1)	Time delay	3	75.78%	24.22%
L.2)	Cost overruns	6	68.83%	31.17%
L.3)	Do not have proper work plans	2	82.34%	17.66%
L.4)	Lack of adequate technology	4	72.78%	27.22%
L.5)	Less involvement of experienced professionals	1	85.34%	14.66%
L.6)	Cannot estimate required time properly	8	63.76%	36.24%
L.7)	Cannot estimate required amount of money properly	5	70.76%	29.24%
L.8)	Low quality products	9	59.87%	40.13%
L.9)	Poor quality workmanship (unskilled labourers)	7	64.76%	35.24%
L.10)	level of trust & responsibilities are not at the expected level	10	43.54%	56.46%

Among those limitations “less involvement of experienced professionals” was analyzed as the most significant limitation. Generally, it was hard to find the qualified professionals’ involvement in the services installation process of informal sector. Most of the workers were identified as unskilled labourers and some professionals were not to the required standards. And the second most important limitation was that they do not have proper work plans. It was identified when considering the services installation, informal sector is taking more time than the estimated time duration. Thus, time delay was in the third rank in the evaluation. This was due to the poor workmanship and improper work plan. Another limitation which was found in the 4th place was inadequate knowledge in technology. New technologies are being introduced by several established contractors who are employed with high financial and technical capabilities which will help to perform the task better and faster. However, this was almost difficult task for the informal sector to get used to newly introduced technologies.

Moreover, the additional fifth limitation was that they were unable to estimate required amount of money properly and the problem regarding cost overrun was in the sixth place. These limitations were taken place due to the less experienced and qualified people’s involvement and poor quality of workmanship.

5.0 Conclusions and Recommendations for good practices

This study identified the most significant issues in the small sector housing construction in case of services installation. The occurrences of services problems were identified in this survey provided that the issues regarding the electrical systems were high. Major impacted problems were namely trip switch failure, current leakage and damages occurred to equipment due to excessive current. Significant failures in electricity generally lead to a huge loss in houses which includes damages to the equipment, entire structure of the whole house, even loss of lives. The next most problems were arising from plumbing system. The major types of issues were identified as water leakage and water seepage through walls. These kind of plumbing dilemmas are occurring in houses frequently and this would acquire a high repair and maintenance cost. The least most problems were identified in Mechanical system which are of minor nature and the main problems encountered were occurred in Air-conditioning unit and not practicing regular maintenance work.

It was proved by this survey that 87.64% of informal sectors and 12.36% of formal sectors were involved in installation of services in small sector housing schemes. Less involvement of experienced professionals, poor working plans, time delay, lack of adequate technology, projects often experience a lot of hold-ups/suspensions and restarts, were identified as some limitations in the informal sector by the house owners. The results is higher repair and replacement cost to the owner. Even though the performance of the formal construction sector is beneficial than the informal construction sector, it cannot be ignored or throw out the informal construction sector completely. Majority of the house owners in Sri Lanka are not financially capable enough to get their work done by the formal construction sector because of high cost.

Therefore, an informal sector of construction industry is essential in a country like Sri Lanka. Recommendations have been made to improve knowledge and awareness of informall sector workers as well as house owners. According to the respondents, majority of house owners have no or little knowledge on services part. Thus, it is very difficult for them to choose the proper workers, materials and hard to inspect the works during the installation time. The best step is to promote hand bills, organize some awareness programmes among individual people. As well, it is important to conduct training programmes, workshops and awareness programmes to improve the skills of informal sector on new technology and new management theories. The institutions such as Institute of contractaors training and development (ICTAD) and other policy making bodies have an important role in initializing, promoting and implementing such approaches. Thus, the expected issues with services instalations in small sector housing construction could be overcome if the suggestions and recommendations given of this research is consider and put into practice.

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Emergence and Amelioration of Students' Creativity through Practice Based Learning in Relation to Design Education

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Abstract

'Practice-based education (PBE) offers the students an invaluable experience to gain knowledge and improve their skills towards diverse fields which prove the realities in the social and physical context.' (Clifford, Macy, Albi, Bricker & Rahn, 2005). This method becomes more significant when it comes to Design education in university teaching. To provide an effective Practice-based education, university education system undergoes a complex and time-intensive process. The main objective of this research is to explore the possibility and suitability of practice based educational system in nurturing the students to build up a design rational and to find out the essential factors to be considered while at teaching and designing projects. This was experimented through a design project carried out for the Level I students of Department of Integrated Design.

*The study describes how student capabilities were gradually developed in forming a design rational by using the **Human body** as a design context. Here the form of education becomes more unique and significant, that their approaches became successful more than to the expected level. It was through practice and experience that the students achieve expected targets in the design project. The final outcome of the project is a result of different activities followed with workshops and immense experiments. A solitary observation was followed throughout the project as to understand how beneficial is practice based education in improving student skills and how the projects must be designed setting out certain goals and objectives with special reference to Design education.*

The results of the research analysis concluded that practice or activity based learning system becomes more effective for design education, when students' physiological and psychological abilities are evaluated and gradually expanded by offering them the understanding about the context, method of integration, theoretical knowledge while developing an own sense for design.

Key words: Practice based learning, design rational, creative thinking, physical and psychological development

Introduction

Design can neither be taught nor instructed. It is through continuous practice and experiment that someone needs to improve his creative skills and design rational. This becomes more vital when it comes to design education at higher educational levels, such as universities. Universities are usually meant for students to research and learn through practice where they are offered with guidance and improvement. Hence the university becomes a lab where he experiments, practices and excels with knowledge and experience. A student as a beginner for design education only carries considerable amount of capabilities for creativity and aesthetics, as he only carries the knowledge extracted from different streams from Advanced Level education. Hence, design or designing means an inexperienced task where the student feels alienated and unexplored. This is when a strong foundation of design education is essential at the very beginning.

Identifying the most effective method on educating designing becomes the main source of research in this paper. The problem arises when penetrating into an answer for, whether objectives of a project set by the academics are achieved by the students through the method of educating design. This can be measured by analyzing whether the set objectives or goals are achieved by the students as expected. However, this all follows a great deal of efforts in programming, organizing and designing a project prior to introduction of it to the students. While designing a project, certain tasks must be set to achieve its optimum outcome, such as (A) setting objectives for students and as well as for the academics (B) an understanding on the students' learning capacity (C) identifying the most suitable method of teaching. According

to Nigel Cross (2001) and Yrjö Engeström (2001) by Peter Goodyear and Yannis Dimitriadis (2013); a theory of 'design for learning' should focus on:

1. 'Who is doing the designing? Who is doing the learning? Who else is involved?
2. Why is the design work being done? Why are the learners doing what they do?
3. What is designed? What is learned?
4. How is the design work undertaken? How does the learning activity occur?

And of course it also needs to account for any significant relationships between the entities (people, places, artifacts, etc.) implicated in the design and the learning activities.'

Then the problem is why a proper learning system needs to be identified? However, reasons for introducing design projects for students must be identified. The main purpose becomes delivering and developing a sense for design to realize three main objectives as; what is design, why do we design and how do we design. The other objectives are acknowledged throughout the process such as; learning of commonly identified design theories and principles, how to apply them at given situations and regulate their own learning and understanding the context around them, where they should work. While these objectives may vary depending on the project, a general focus on its outcomes are expected. The earlier researches prove positive aspects derived from practice based learning within the two distinguish systems. Thirdly, the paper describes how such methods are implemented. Hence, the project is comprised of multi-disciplinary activities arranged in sequences, where the student is upgraded at different levels of learning. The research explores and proves above findings through a project introduced to Level I students of Design.

What is design?

Before penetrating into how designing should be accomplished, a study should be carried out to understand what is design and why design is required. A definition is hard to find when the question asked 'what is design?'. However, the answer always relies between science, technology and art as two extremes of a path. Science and technology withstand continuous changes and improvements through time and experiments. Art, on the other hand, is an expression or communication of emotions and ideas, typically exhibited through a visual form such as painting, sculpture, music, literature dance. 'Design' floats in these two extremes. Although it becomes sometimes difficult to separate design from art, it is not purely an art, as it does not stand for mere amusement, appreciation or to provide visual sensation.

'We cannot say science, art or technology does not affect design, but the designer cannot escape the influences of these three broad categories of intellectual endeavor. One of the essential difficulties and fascinations of designing is the need to embrace so many different kinds of thought and knowledge.' (Bryan Lawson, *How Designers Think*, 2005) Usually this realization is the process rather than the end product of design which chiefly interests in this research.

An extravagant design will always reach fame through eternity, such as a piece of art, and will be sometimes a problem solving product which is improved through science and technology. Designs such as the Barcelona Chair by Mies Van Der Rohe in 1929 stands through time and his design became iconic, which fits today's interiors alongside the furniture designed today. The unique bottle design in a contour shape by Coca-Cola from 1916 proves how influential a design can be to achieve success and popularity through time. Likewise, the most famous designs and many other utensils that make things better for people have stand through time while providing the optimum feasibility and aesthetic sensations for its user.

'What Design Can Do! is unique, in that it highlights the role of the designer in imagining and realizing a more sustainable future world. Thus for all those whose daily lives are affected by design which are commonly all human beings. Because design in its strongest and most effective form is about smaller and larger changes for the better.' (Christine De Baan, *What Design Can Do!*, 2011).

Design education

In relation to the research topic, the findings prove, a student needs to understand the unique quality that a design should carry. Developing a sense for design on students' mindset will be the key factor for such educational system. An intuitive sense for design does not emerge spontaneously. It should undergo a moderate and steady process obtaining the student, a physical and psychological development. Mere theoretical education does not accomplish student requirement for design education. This is when practice based education takes place in facilitating the student with optimum knowledge and experience. A task, when practically experimented and experienced provide more solidity and strength, rather than with theoretical work.

‘It seems almost impossible to learn design without actually doing it. What is certain is that design is a distinctive mental activity, and we shall progressively explore its characteristics through the mindset of student. If we are not careful then design education might restrict rather than enhance the ability of the students to think creatively. Design is also a highly complex and sophisticated skill. It is not a mystical ability given only to those with recondite powers but a skill which, for many, must be learnt and practiced. Beginners however must first analyse and practice all the elements of their skill.’ (Bryan Lawson, 2005) ‘Practice based education provides a suitable idea that, it is what students *do* that really matters.’ (J. Higgs: Practice-Based Education: Perspectives and Strategies, 2012). In these perspectives on the educational significance, mental and physical activities of students are synchronized together to gain better results. Thinking and reflection, as well as action are mainly concerned in this scenario. Thus, the two activities can be hardly separated.

Since the quality of students’ activity results in what they learn, it is necessary that educators think hard about what influences student activities. It is also questionable whether the academics at a design education institution can serve as educators for students. We cannot teach them how to design, but only guide and instruct them for the correct path to achieve a successful design, as the sense of design births spontaneously.

Practice based education can be introduced in different perspectives and can be identified as an effective, collaborative and enjoyable approach towards teaching systems. They can experience practice and practice/ context relationships. The opportunity to understand the community and adaptation to the context is another positive aspect. Awareness about latest technology, industrial exposure is also obtained at such situations. However, to offer such capabilities, projects should be planned and well organized by educators, which is extremely a hard role. While designing a practice-based learning project, they will need to focus on certain areas which will be explained in the forthcoming sessions. The education system explained above becomes more significant when it comes to Design within the university education. When understanding the person, persons or the context who’s experiencing a designed product or service is essential, understanding their mindset and requirements also become important. To obtain such knowledge, the designer needs to work within the context and experience the surrounding. This is another place where practice based education becomes a fundamental requirement in Design education. In the forthcoming sections the effectiveness of this learning system will be discussed in relation to the design project carried out by the Department of Integrated Design.

Research method

Context based learning becomes the initial stage for beginners in design education. As the third design project for Level I students, the Human body becomes the context in understanding the core values of design theories. The intention of identifying the Human body as a design context is to explore the unseen artistries as the space within and in between body and outer environment. Further these artistries were intended to convert into a non-verbal medium for communication. ‘Space In Between’; a project gets designed in exploring the unobserved inventions in and within the body.

The idea of context based design learning is a major task that demonstrates the working environment, culture, society and other physical and psychological factors affecting designing a product or a service for the beginners. The designers must constantly build interaction with the context, to where he is designing. These interactions can take the form of physical or virtual connections. It creates an environment that educates them, enabling them to make more informed design decisions. When the body becomes the context for designing, it is more crucial and interesting that one will need to explore his own body. Hence, the project was planned to let the student start from the most reliable method to understand his own body. Later on, this was developed into contact with other bodies, building interactions, non-verbally. At certain other stages, the bodies and bodily connections had to be synchronized/ contrasted or modified to the physical environment to deliver different types of messages. As the main objectives the students were expected to understand the fascinating characteristics of the body identify the spaces created within and in between the body and physical environment, identify how body can be used as a medium in communicating a message and explore different levels of idea generation by adding extensions or external elements to the body. At the end develop a sense for design and understanding body as a design context become the major intentions from the viewpoint of academic curriculum. The project was planned, setting out the above objectives and goals methodically accelerating the learning abilities of the students. The project initiates from days and weeks before the final event, developing the students design thinking ability mentally and physically through several stages. It was designed with workshops and activity based learning where the students gradually understand the possibilities that the body can be used as a strong medium. They study and experience through taught discussions and experiments. The workshops initiated the students to work independently, freed by the restrictions and breaking the feeling of modesty. A five days’ workshop was organized in Dambulla, where the students were assigned to develop certain ideologies and understand through activities. These were continuously guided and instructed by the academics. The batch containing forty four students were categorized into five groups and

were offered with a mentor for each team to guide them with students' work. These mentors were some practitioners excelled in different streams within the field of design. Our intention was to extract their experience which they practice in realistic situations and provide their expertism in reshaping students' mindset. It was an asset that the students also had to work with twenty five foreign undergraduates from diverse fields, in their internship to achieve experience in a different cultural and social background. These students were from Russia, Ukraine, Pakistan, India, Columbia, Poland, China and Egypt. A blend with people from different socio-cultural backgrounds brought a new atmosphere to the project while sharing the expertism within the individuals.

The body and space as undetectable forms from each other, was made a question on how to realize the artistries they generate when identified and exaggerated. Human body itself is a magnificent work of art by nature, when touched by its form, shape and volume. Above all, the body with its movements expresses unlimited boundaries enhancing most impressive feelings. This is where the 'space' in, within and in-between the body can be expressed, exaggerated and explained. To identify these diversifications, experimenting is an essential part. To feel its variations one can understand only through practice or live experience. Initiating from the body itself, the students were driven for progressive approaches to identify its unique qualities and then make additions for exaggeration. These experiments guided the students to invent new ideas and unimaginable outcomes to reality.

The journey began in exploring such elegances by the touch of skin, identifying its sensitivity to self and other. Non-verbal communication through gestures and touches was the first step. Secondly, different bodies were bonded physically in breaking the boundaries within the personal spaces. At this time, the approaches were extremely successful in breaking the personal spaces in between the bodies. Students' modest and diffident reactions to touch each other made barriers to build interaction. This is when the students are dragged on to a floodplain and start with simple mind blowing games. Deliberate improvements were envisaged while the games changed to psychological approaches from physical approaches. As the next stage, the body, bodies and bodily spaces got gradually minimized when bound together in recreating different expressions within a context. The bodies got camouflaged, contrasted and elaborated to the surrounding. Through experience and experiments the students studied what happens to their bodies when mud is applied over the bodies and how different bodies are linked to each other forming shapes and forms in camouflaging and creating contrasts within the context.

Each night, we had discussions with all the teams, in which they expressed their experience on the floodplain and the activities carried out. The playing on the floodplain was totally a new experience for the foreign students which they had enjoyed a lot, and even for the local students, that reminded of their childhood activities. Applying mud on the skin brought them another new experience first as a disgusting feeling and later discovering it as a form of layer to cover their skin from heat. When the mud started to get dry and crack, they felt the sensitivity of skin and how that reacts differently on different parts of the body. We carried out our discussions further into talking about the skin. As one of the mentors asked from the students, what do you have on your skin, as resemblances of past experiences and memories? Few students started expressing their thoughts on childhood memories and present experiences. The majority showed reluctant reactions to talk openly. Hence, a decision was given to express any of their memories attached to the skin, to be expressed on a paper, by the next day morning. But, the medium of communicating the idea was only through a painting on the body transferred to the paper as a print.

Then, in the early morning of next day, the walls were filled with many extreme stories of their life through a body print with lesser words. All the prints were made anonymous. Different parts of the body were printed on the papers, which was quite unimaginable at some instances. However, the result was successful and we started to bring about discussions by looking at those painting. The teams created different stories, which ultimately formed into a concept for each to continue with the day activities. The teams formed concepts and came up with ideas to express it, through the body itself. Once again they started applying body paint on the skin, as it was converted into a canvas to translate their ideas. An expedition of skin began when it was converted into a canvas and when the canvas got painted. Some groups transferred the prints once again on to a fabric to determine the negative shape and forms of body. The fabric got modified with improved brush strokes and cuts at predetermined distances and wrapped on the body and sometimes on bodies to emphasize its expressions through movements. Through numerous attempts and experiments the students' outcome was overwhelming and unbelievable. However, these outcomes were achieved with students' strong interaction and practice through the guidance and influences from instructors. Such consequences are constantly not pre-planned results but incredible innovations which will guide and stimulate students for further approaches.

As the next stage students were guided to use external elements and body attachments to see the overemphasis of body. A different path at body paint; stressing feelings with external elements such as mesh and ropes, tubes, boards gave an enhancement to the body while reaching unlimited boundaries and an expression of space within the 'body'. They were recorded for later references, as an approach for the final event on the last day of workshop.

Simultaneously some groups were influenced to use technological advancements according to their concept. Casting shadows and reflections on the painted body through multi-media projections was another approach by another group to identify the body outlines and the spaces in-between. Using the technology available at the workshop, the team arranged a set up to perform their ideology. Number of attempts took place to make the body disappear in a moment and once again appear with a second skin. Their experiments became successful when the movements sometimes got synchronized and contrasted giving the audience an unimaginable expression of art.

On the day following, the teams were given the opportunity to develop their concepts further as we took them into a different context, a place where nature's beauty was at its extreme. The findings of the students now had to be synchronized with the surrounding. The students developed their concepts reacting to the context while recording them through videos and photographs. It was evident that the students' minds were freed suddenly, to express their own ideas, as they were diverged from the monotonous life at the accommodation. They came up with innovative ideas, as to how they can express their concepts in a better way. Spending the day near a dyke connecting to a lake and paddy fields on either sides, the students had progressive approaches towards the main theme, by working with the context.

At this stage the students' mental and physical approaches towards the final event were appealing and outstanding. This was a result of the progressive improvements that took place throughout the past experiences and experiments through practice. The ultimate expedition on 'Space-In-Between' through body begins at a state where students' mind-set is profoundly aligned, structured and secured.

The final day at the workshop, Dambulla we focused the students on presenting the findings of each group to a set of audience including their own batch mates and the academics. The event had to be organized by themselves to be presented at night, hence they had to think about the light set ups, a stage for performance with a proper background, music and essentially their costumes, props and performances. From the day before, the students started working on preparing props and costumes required for the event. In the meanwhile, the method of communication was also important. They developed their concepts to be communicated through choreography. Although the students of design education were less talented in choreography, they formed their performances with the assistance of a professional, which also brought out their hidden talents. The students were also expected to record and later analyse how they had buildup concepts and interacted with each other during the design process. The presentations of each group started. Although the students had a lesser amount of resources to organize an event in a remote area, their attempts on stage set up, lights, music and multi-media projects were quite outstanding. On the contrary, all the presentations took the mode of a narration which simply represented a drama with certain sequences. During the performances, the students realized themselves, how their own concepts have been deviated from their original ideologies. A narrative story was not the ultimate expectation of the audience.

As the second stage of the project, the findings were brought to the university premises for further improvements. The students' negative attitude towards the event in Dambulla influenced them for a strong desire to re-build their ideologies. This is when, the instructors start re-designing the project for an advanced level of communicating an idea towards a larger community. This is where intra-personal communication being transferred to inter-personal communication. We developed an ideology with an unspoken social issue trying to be presented to a larger audience. The medium of communication is still the 'body' adding certain other technological advancements for its quality and exaggeration. This is where different concepts derived from the workshop are merged together to form a fusion of performing art exaggerating the body, space and beyond as a medium of communication. The bodily expressions and spaces created within the bodies will be a medium utilized to convey a message that addresses a transection of society. The conclusion will explain how body and space is a persuasive source in communication and design.

As this ideology was introduced to the students taking 'body' as the main medium of communication to address a community, they needed to imagine how body as a being get disappeared within the society. The ideology emerges within the students themselves as to what they feel about human disappearances in general. They began to realize that disappearance can occur in two different ways. Self-imposed disappearance and enforced disappearance can arise two different consequences. The former describing spontaneous disappearances where people hide themselves from society or own families for personal reasons whereas the latter explains forced disappearances through a powerful hand or state. However both these scenarios are put together at a single event, explaining its consequences at different contexts. While an initial idea was formed, the students were asked to build up the story on how they are communicating the message of human disappearances. The story required to have the sequences of screens and the transition from one to another. After a number of tutoring sessions and discussions, the story was finalized as an event to be presented to the university community. The reason for selecting the students of university as the audience becomes the tendency to share almost same ideologies as of the design students, because of their age, educational and social level. Also on the

other hand, it was necessary to refrain from political influences from other parties and state. Project needed to be designed that the students get inevitably integrated with the context or working environment. This working environment can be mostly directing to diverse social communities. Adaptation of students' mentality to work freely, without hesitation is important to extract their concepts and ideas. However, a challenge is always upfront for the students as the working environment may withstand continuous change. Hence, their confidence is pre-built for unplanned factors. On the other hand, project was designed to realize the goals of developing students' technical, professional capabilities, forming their own identities, and supporting their development as positively contributing as designers. Hence, the event included multi-media projections, building and body mapping as supportive mediums in delivering the message. Building mapping required immense contribution and concentration, to design the screen according to the background. The back wall was constructed in a grid pattern, so that the images/videos casted on the wall had to synchronize, to avoid distraction and loss of clarity. The method of communication through body was also concerned greatly. Through choreography, a part of the message was delivered, while composing suitable music tracks. This followed designing costumes for the dancers, their makeup and suitable props. The event also required a setup of lights to aid the performances. Every detail had to be pre-planned by assuming the locations of the performers according to their changing movements.

The ending of the event was the ultimate requirement that the students had to think about. The ending of such message needed to be delivered with a heart touching thought to be felt by the audience. At this stage, the students together with the academics came up with the ideology that, disappearances always follows a hope that the person who is disappeared will come back on some day. Taking this as the concept, the ending was planned to light up hundreds of candles and shared even among the audience, grabbing their interaction. This imitated a thought of hope. Then the most crucial problem arises on how to attract a huge audience to the determined location. If the event with its actual message is advertised the tendency to gather a large audience was uncertain. Hence, the students came up with the idea that, they can organize a musical event with the intention of grabbing people. Finally the location was organized with proper planning and setup design. The students had to divide certain responsibilities among themselves to manage a smooth flow on the event, while on air.

The location becomes the courtyard of the canteen two, where an appropriate context was possible to be formed with the help of its surrounding. A large back wall, to be used as a screen, the spaciousness of the courtyard to accommodate a huge crowd, the different levels of the landscape for the performers to choreograph grabbing the interaction of the audience were some of the assets. The context was subjected to certain other modifications, to improve the quality of event and acquire the integration of audience.

A Rock musical experience is created with the intention of gathering a large audience to the determined location. 'Rock' music was concerned the most effective stimulant to gather a huge crowd and most suitable style for which we can generate our idea. While people start to gather, suddenly, the story begins to unfold at the courtyard of the canteen when the audience is at the climax of excitement with music and dance. A live act is created and performers enter the stage through the audience. While performing, the audience gets distracted on performers' sudden appearance. Images and videos get projected on to the bodies of the performers while at dance, when a video mapping is casted on the back wall. The audience start realizing the story and mutual interaction is created. The performance brings the audience to its climax when the candles are lighted and shared among everyone who gathered for the event. The act ends illuminating a light of hope in the heart of audience.

This was the story that was lively unfolded to hundreds of audience, by Level I students of Design, as their third design project. The story holds much depth and meaning while on the other hand the method of delivery is even more compelling. A live performance, a live composition of technology, a message delivered lively extracting the interaction of the audience is three massive efforts for the beginners of design education. Above all the final stage of the project carried immense efforts on strategic thinking where planning, understanding the audience and reacting according to their reactions were essential requirements. To compose such extensive event; enormous efforts, experiments and research were required. Making the mind-set of students' for a better approach is the most challenging. While improving their design ideology on 'Space In Between', it was also necessary that the educators influence and acknowledge the students on the working environment. It took days and weeks of hard work making the process continuously improved through assessment and evaluation. After all, the design project achieves success and was learnt through practice, experiment and implementation.

Hence, the project outcome is merely an event rather than an assignment or examination. The experience, knowledge and creative skills achieved will be an asset for the students to react at different contexts in the future, with relation to 'Design'.

Conclusion

'Design' although not having a definite interpretation, is identified as a process comprised of certain levels starting from research and ending with implementation as a service or product in solving a problem at certain time or bringing purely an innovative thinking into reality through aesthetic sensations and usability for its user. Hence, a designer must act and practice in such a way that the user or users are satisfied with the product or service offered by him. Here, the rational of a designer becomes more effective and fundamental in communicating his own idea. Although a designer's creativity and thinking ability is an interpretation of self-developed individual, his education and learning also effects the way he reacts to a design solution. This is when identification and formation of an appropriate educational system in developing a sense for design becomes important.

The paper begins with a study of identifying such educational system through a project carried out for the Level I students of design education. Here, the practice based education becomes more prominent and effective in nurturing the students with technological, professional knowledge while forming their own design rational. As the research method, the paper presents how this is converted into a Design project and analyzes the consequences and learning outcomes through students' achievements. They are explained within the process carried out through a project. Thus, the main objective of this research is reached and understood that certain methodologies affect students' learning procedures.

The objective of the design project becomes, identifying 'body' as a medium of communication. Thus it is imperative that the project must be designed by the academics in such a way, that the students achieve intended knowledge and experience by the end of the project. As explained, design is not a subject to be taught. We can only help them to build a sense for design while providing commonly accepted design theories, technological and professional knowledge. The exploration of body starts with activity based workshops at out-stations planned by the academics. To identify the body, it is essential that students start analyzing their own body on how it feels and reacts at given situations. Next, the space created with in the body and expressions when combined with other bodies were identified through certain activities. Reacting and working within a given context becomes the next challenge for the students, where they learn understanding the working space and surrounding is essential for their outcomes. Presentation of their findings to another through a conceptual approach was necessary as the final phase of the project.

All these activities reflected a gradual development of students' thinking process during different stages of activities. Thus, the academics must understand what and how the students' progression must be maintained through activities. Some commonly understood factors affecting a fruitful learning system for design education are envisaged as practice based learning. This follows; projects designed to realize the goals of developing students' technical, professional capabilities, forming their own identities, and supporting their development, get inevitably integrated with the context or working environment adapting students' mentality to work freely, without reluctance to extract their concepts and ideas. However, it is essential that the academics understand students' capacity to avoid alienation and desertion. A progressive development of the mindset is essential to bring the student to a physically and mentally stronger situation. Student progression must be appraised and evaluated on an ongoing basis while building up partnerships between learners and academics, workplace learning educators and practitioners, professional groups and finally the society with whom they will be working in the future.

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Modeling Colombo's land uses with Metronamica: a demonstrative approach

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Abstract

The enormous complexity built into cities makes them difficult to understand for any purpose. The ever changing land uses in any city is not an exemption, despite its importance for planners to know at some level of certainty. In order to overcome this difficulty Cellular Automata (CA) models are widely used in the field of urban planning as means of simulating land use changes with adequate bearing on the complexities associated with urban systems. This paper is a demonstrative attempt to model the land use changes in Colombo Metropolitan area in Sri Lanka between 1987 and 2010, within a modeling framework developed with CA based simulation application: Metronamica. Simulation results are assessed and validated using visual comparison and statistical methods. This study is placed in a context where the current planning practices in Sri Lanka are in need of robust methods and versatile techniques to comprehend land uses in rapidly growing urban areas.

Keywords: *land use changes, urban complexity, simulation, cellular automata (CA)*

Introduction

'...Our traditional image of the city no longer holds. Cities appear much more complex than we generally assume...' (Michael Batty, 2005)

Urban systems are becoming ever larger and increasingly complex as urban economies, social and political structures and norms, and transportation and other infrastructure systems and technologies evolve (Waddell & Ulfarsson, 2004). The situations generated with the growth of urban areas raise vital issues that need to be considered in the planning process (Pinto & Antunes, 2010). Therefore, one of the important subjects of concern in the field of urban planning is to predict and simulate the said trend of land use transition. However, projections without a sufficient understanding of the system under study embody a greater degree of uncertainty due to the numerous unknown factors involved (Cheng, Masser, & Ottens, 2014).

To overcome this situation, urban simulation models have been developed in many approaches. Initially developed urban land use models were based on the assumption that urban patterns are the changes in the equilibrium within the city system (Lahti, 2008), but these were having many limitations such as the centralized structure, lack of detail, little usability, flexibility and realism (Torrens & O'Sullivan, 2001). They could not successfully capture the complex nature of cities. These traditional models were followed by complexity models or geosimulation models that were developed considering the bottom up approach of modeling. Among a wide range of modelling techniques that are used for urban simulation, Cellular Automaton (CA) has been considered as one that could successfully capture the complex nature of cities. CA is defined as 'an automaton of a processing mechanism with characteristics that change over time based on its internal characteristics, rules and external input' (Benenson & Torrens, 2004).

The importance and the need of employing such tools in the planning process are widely recognized in Sri Lanka in a context where the conventional urban planning practices lacked sound methods to predict the growth scenarios under different circumstances envisaged by development decisions.

This paper is a demonstrative attempt towards modeling the future land uses of Colombo, based on current trends of development using the Metronamica model, which is a cellular automata based RIKS (Research Institute for Knowledge Systems)' Spatial Decision Support System (SDSS) for urban and regional planning applications (RISK, n.d.). The first section of the paper briefly discusses the concepts associated with the CA, its applications and the principles at the base formulation of Metronamica model. The second section elaborates the methodology of the study, data preparation, model calibration process and applications.

Urban Simulation Modelling, Cellular Automata & Metronamica

Cellular automata (CA) gets its name from the fact that it consists of cells – like the cells on a checkerboard – and that the cell states may evolve according to a simple transition rule, the automaton (RISK, n.d.). A conventional cellular automaton consists of: A Euclidean space divided into an array of identical cells, for geographical applications a 2 or 3-dimensional array is most practical; A cell neighborhood, for flow and diffusion processes the 4 (Von Neumann neighborhood) or 8 (Moore neighborhood) adjacent cells are sufficient, but for most socio-economic processes larger neighborhoods are required; A set of discrete cell states; A set of transition rules, which determine the state of a cell as a function of the states of cells in the neighborhood; Discrete time steps, with all cell states updated simultaneously (RISK, n.d.). A cell's new state is a function of all the states in the cell's neighborhood at the previous moment of time (or during the previous generation). We calculate a new state value by looking at all the previous neighborhood states. The fundamental formula for calculating a cell's state at any given time t is:

$$\text{CELL state at time } t = f(\text{CELL neighborhood at time } t - 1)$$

The CA model managed to capture the complexity in urban systems by capturing their characteristics of emergence, self-similarity, self-organization and non-linear behavior of land use changes with time (Michael Batty & Longley, 1994). The use of tools that can help in the understanding of the above-mentioned characteristics is important to gain knowledge about the patterns and mechanisms behind urban dynamics (Sanchez, Z. Vojinovic, Price, & Waly, 2011). If predominantly based upon local interactions, complex systems can be modeled as cellular automata (Blecic, Cecchini, Prastacos, & Trunfio, 2004). Inherently bottom-up, friendly to use and interactive CAs can be an effective way to test and evaluate planning actions (Blecic et al., 2004). What makes CA-based models particularly attractive is their ability to “spontaneously” give rise to global dynamics out of local interaction rules (Michael Batty, 2005). Furthermore, these tools do not tend to simplify reality, but rather employ its complex nature, which makes them an effective instrument for the exploration of spatial dynamics (Blecic et al., 2004). CA were first introduced in the 1940s by John von Neumann, the founder of game theory, and Stanislaw Ulam, who worked in the Manhattan Project and did intensive research in the field of Monte Carlo simulation (Pinto & Antunes, 2007).

When considering the use of CA in urban studies, several CA based applications are proposed and applied to various geographic - spatial phenomena and to understand the growth of different urban regions (Pinto & Antunes, 2007). During the next two decades, a great effort was made to develop CA-based models: Couclelis (1997), White and Engelen (1997) and Michael Batty (2005) had intensively worked on different theoretical underpinning issues regarding CA application to urban studies. M Batty and Xie (1997) and Clarke, Hoppen, and Gaydos (1997) studied the application of important evolutions of CA to real world problems, Semboloni (2000) studied urban infrastructure development, O'Sullivan (2001) used an integrated approach based on CA and on graph theory to study gentrification and Silva and Clarke (2002) had calibrated a CA model- SLEUTH (slope, land use, exclusion, urban extent, transportation and hillshade)- to simulate the urban growth model for Lisbon and Porto, Portugal, while Barredo, Kasanko, McCormick, and Lavalle (2003) made applications of previously developed CA models to large metropolitan areas.

As stated above, several cellular automata models have been developed during the past years to simulate the land use changes and to understand their complex nature. 'Metronamica' is one of the modeling applications which have successfully captured this complex nature. Factors affecting land use changes in a particular context are dependent on the characteristics of the particular area. Therefore there is no set method to simulate land use changes in cities. Metronamica consists of a dynamic, spatial land use change model and can optionally include a regional migration model and a transport model for modeling congestion and traffic pressure on the transport network (RISK, n.d.).

Metronamica simulates land use changes based on a number of different drivers. First, there are external factors such as population growth or the decrease of natural area that determine the demand for different land uses. Populations and jobs are divided over the regions, based on how attractive these regions are to people and businesses. This attractiveness depends again on a number of factors such as the existing activities and local characteristics such as the accessibility. Finally, within each region, the land uses for every location are determined based on socio-economic factors (e.g., will a business flourish in this location?), policy options (e.g., are there policy rules in effect that restrict new housing development in this location?) and biophysical factors (e.g., is the soil suited for agriculture here?) (RISK, n.d.).

The Study and the Methodology

The Colombo Metropolitan Region (Western Province), Sri Lanka is selected as the case study area of the study. The Colombo Metropolitan Region consists of three districts; Colombo, Gampaha and Kalutara. The total land area of Colombo Metropolitan region is about 3,745 square kilometers.

As per the Department of Census and Statistics (2012) the total population is 5,835,852. Over the years, Colombo had become the main economic and administrative hub in the country and the western province is the main contributor to the GDP of the country. Relatively, a large portion of the employments and other infrastructure facilities are concentrated within this region that makes the region with the highest population concentration. Availability of data was another crucial factor that justifies the selection of case study area. A conceptual framework was developed considering the factors identified through literature review to simulate the land use pattern in the Colombo Metropolitan region (Western Province) with the effect of transportation, zoning regulations, interactions between land uses and physical suitability for different land.

Figure 012: Colombo metropolitan region (Western province)



Cell structure

Cell structure is considered as the first component of a CA model. The inbuilt regular cell structure of the Metronamica model is taken for this study. The cell size for the model was considered as 100mx100m (2.47acres).

Cell states

Eleven cell states were assigned for the model by taking eleven land use categories. Namely: highly urbanized, moderately urbanized, less urbanized, very less urbanized, waterbodies, paddy, marsh, forest, other crops/ cultivation, sand/beach and rocks. In this, highly urbanized, moderately urbanized, less urbanized, very less urbanized, paddy and marsh were considered functional cell states, while Forests, rocks, sand/ beach and water bodies were taken as feature states- fixed cell states - which will not change over time and other crops was considered as a vacant land use. Accordingly the functional cell states can change its states with the model simulation. This means that land use dynamics are allowed in six land uses classes. The potential probability for change and the strict legislation framework

existing in the country on preserving forests, beach and water resources had been taken to consideration in assigning fixed cell states.

As the main consideration is on simulating urban growth pattern, the data sets were prepared accordingly. In the original map layer there was no land use category named urban. Instead there were categories named built up and homestead. So these two land uses were categorized into four urban categories named highly, moderately, less and very less urban based on the population density, intersecting the land use with population data using the Arc GIS application.

Neighborhood

The extent to which land use interactions occur is incorporated to the CA model through the neighborhood component. For each location, each cell that is, the model assesses the quality and the character of its neighborhood. As Pinto and Antunes (2010) argued, neighborhood component plays a key role on the overall CA modelling framework since it's representing the spatial extent of interactions, embodying Tobler's theory on geography; "everything is related to everything else, but near things are more related than distant things" (Tobler, 1970). The neighborhood for the standard Metronamica model is defined to be a circular area with a radius of 8 cells containing 196 nearest cells (Delden, Escudero, Uljee, & Engelen, 2005). The same is adopted in this study. In spatial terms the neighborhood in CA represents a distance of 800m from the considered cell.

Transition rules / Neighborhood rules

The dynamism of the CA models relies on the transition rules of a CA model. Cellular Automata models consider various factors in transition of land uses. The pre-defined rules of the original model are used in the study. In the Metronamica cellular automata land use model, there are pre-defined rules. It considers four factors; *neighborhood effect*, *suitability*, *accessibility* and *zoning*. Transition potential of a cell is determined by the result of all these four factors. Accordingly, the transition potential for land use function f in cell c (${}^tP_{f,c}$) is calculated using the following equations:

$${}^tV_{f,c} = \begin{cases} {}^tR_{f,c} \cdot (1+e) & \text{if } \alpha > 0 \\ {}^tR_{f,c} & \text{else} \end{cases}$$

$${}^tP_{f,c} = \begin{cases} {}^tV_{f,c} \cdot {}^tS_{f,c} \cdot {}^tZ_{f,c} \cdot {}^tA_{f,c} & \text{if } {}^tV_{f,c} \geq 0 \\ {}^tV_{f,c} \cdot (2 - {}^tS_{f,c} \cdot {}^tZ_{f,c} \cdot {}^tA_{f,c}) & \text{else} \end{cases}$$

Here transition potential is a multiplication of neighborhood potential (${}^tR_{f,c}$), suitability (${}^tS_{f,c}$), zoning (${}^tZ_{f,c}$) and accessibility (${}^tA_{f,c}$). If a stochastic perturbation is included, two extra factors are taken into account: a random value drawn from a Weibull ($1/\alpha, 1$) distribution (e) and a parameter that controls the extent of the random effect in the potential (α). The value of this last parameter must be in the range $[0,1]$. For vacant states the transition potential is: ${}^tP_{f,c} = {}^tS_{f,c}$ (RISK, n.d.). These four factors have been calculated using several algorithms separately. The findings of this paper are based on the simulations carried out with the neighborhood effect, suitability, and accessibility factors.

Neighborhood Effect

Neighborhood effect is dependent on the interaction of different land uses with each other. In the model, the neighborhood distance is 8 cells. It will create a sophisticated model if all the cells were assigned a value. So the influence functions are transformed to splines defined by only four points rather than calibrated to all 30 points.

The points which give the influence functions are (0, inertia), (1,a), (d,0) and a point between the second and last point (RISK, n.d.).

$${}^tR_{f,c} = \sum_{c' \in D(c)} w(d(c,c')) \cdot f'(c')$$

${}^tR_{f,c}$ = The neighborhood effect in cell c for land use f at time t .

$f(c)$ = The land use occupied by cell c at time t .

$d(a,b)$ = The Euclidian distance between cell a and cell b

$w_{f'}(d)$ = The influence function, expressing the strength of the influence of a cell with land use f' on land use f for each distance d in the CA neighborhood.

Suitability

Suitability maps are based on physical characteristics of a location. These remain constant during simulation, but affect the transition rules. There is no algorithm which is applicable. The value applied during the map preparation will be taken into consideration.

Accessibility

Accessibility is an expression of the ease with which an activity can fulfill its needs for transportation and other infrastructure in a particular cell based on the infrastructure network. The accessibility is calculated per land use function. In the model, four types of accessibility are considered; local accessibility, zonal accessibility, implicit accessibility and explicit accessibility. The total accessibility is calculated per land use function and only changes if the user changes the zonal accessibility parameters in the transport model or the infrastructure network or the accessibility coefficients. In other words, the importance of different land use functions of different elements of the network is incorporated in the land use model. Total Accessibility of a cell is defined as:

$${}^tA_{f,c} = \begin{cases} {}^tEA_{f,c} & \text{if } f(c) \in LU_I \\ {}^tZA_{f,z_c} \cdot {}^tLA_{f,c} \cdot {}^tIA_{f,c} \end{cases}$$

${}^tEA_{f,c}$ = the explicit accessibility of cell c for land use f

$f(c)$ = the land use occupied by cell c

LU_I = The set of impassable land uses

${}^tZA_{f,z_c}$ = the zonal accessibility for land use function f in transport zone z_c , the transport zone, in which cell c is located

${}^tLA_{f,c}$ = Local accessibility of cell c for land use f

${}^tIA_{f,c}$ = The implicit accessibility of cell c for land use f (RISK, n.d.)

Since, only the land use model has been used in this study, the zonal accessibility has not been considered as it is based on the generalized cost from a transport zone to origins and destinations. In the Metronamica application, this was calculated through the transport model of the application.

Local Accessibility

Local accessibility represents the extent to which the need for the presence or absence of the transportation network of a land use can be fulfilled. Local accessibility of cell c to link type 's' for land use 'f' is calculated by;

$${}^tLA_{s,f,c} = \begin{cases} \frac{a_{s,f}}{D_{s,c} + a_{s,f}} & \text{if } a_{s,f} > 0 \\ 0 & \text{if } a_{s,f} = 0 \\ 1 - \frac{|a_{s,f}|}{D_{s,c} + |a_{s,f}|} & \text{otherwise} \end{cases}$$

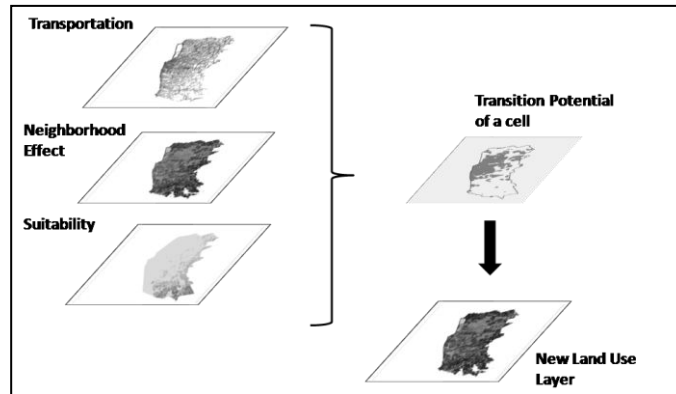
${}^tLA_{s,f,c}$ = Local accessibility of cell c to link type s for land use f

$D_{s,c}$ = Distance (in cells) between cell c and the nearest cell that is covered by link type s at time t

$a_{s,f}$ = Accessibility distance decay parameter, expressing the importance of good access to an infrastructure element of type s for land use f (RISK, n.d.)

Implicit accessibility takes one of two possible values for each land use class; one for urbanized areas and one for non-urbanized areas (RISK, n.d.). The explicit accessibility is defined as the areas occupied by some specific land uses – such as lakes – which cannot be crossed and which should be taken into account when considering the distance from a certain location to the nearest link of a certain type (RISK, n.d.).

Figure 02: Conceptual illustration on the modeling framework



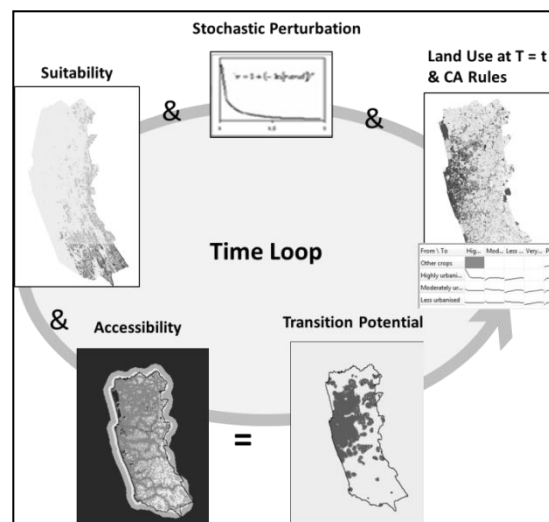
Calibration framework

CA models need to be calibrated in order to ensure the best possible application between the simulated outcomes and the reality that is being modeled. The time step of this model is taken as one year. During each time loop, the model is dynamically evolved with the mentioned algorithms of each factor. Figure 03 represents the overall modeling process.

Within the scope of this study, the tools available for the model validation in the Metronamica are used to test the calibration results. Further, it is required more time for validation for every new rule introduced. Visual inspection of the simulated maps is, of course, an important method used to validate the result, but the modelling tools and the Map Comparison Kit offer a wide range of methods to qualify and quantify the results (Fertner, Jørgensen, & Nielsen, 2012). The Map Comparison Kit was developed by the Research Institute for Knowledge Systems in the Netherlands and was obtained with the application.

Global measures were used to compare the global performance of the model, focal measures to compare the similarities in a certain radius of a cell and local measures to analyze the analogy of single cells. In this paper, the validation is done using global measures by analyzing the total number of cells in a certain category that have changed in simulation and reality. The local measure used to assess the local performance of the model and evaluated using the contingency table and Kappa simulations. (Fertner et al., 2012).

Figure 03: Modelling process



Neighborhood influence parameter

Neighborhood effect was defined based on the attraction and repulsion between different land uses. Among the land use categories, a set of land use pairs having high levels of interaction were selected. The rules were defined to match the observed interactions of land uses and with the knowledge available on these. Then the model was run until the end of the calibration period, and the final land use map generated by the model was compared with the actual land use map of 2010. Then the similarity between two maps was checked. When the maps did not approximate enough, the rules were changed, and the model was run again. This process was continued until having a high degree of similarity between the model output and the real map. The values of the influence were based on the knowledge taken by literature review. Not the value of influence, but the relative influence is taken to decide the transitional potential.

Accessibility parameters

Accessibility parameters were set considering the influence on functional land uses by different types of roads. Accessibility for urbanized land uses were considered more important than the other land uses. So the accessibility parameters were defined accordingly. Marsh, water bodies, sand/ beaches and rock/ quarry land uses were considered impassable land uses for networks.

Table 01: Accessibility parameters for the model

Road Category	Highly Urbanized		Moderately Urbanized	
	Distance Decay	Weight	Distance Decay	Weight
Main Roads	1 km	1	2km	0.7
Minor Roads	500m	0.75	1km	0.7
Jeep/ Cart Tracks	250m	0.5	500m	0.6
Footpath	50m	0.2	100m	0.3
Railway Stations	500m	0.1	500m	0.1

Preparation of dataset

Data and data sources

Datasets required for the model were basically collected from the Survey Department and the department of Census and Statistics. Land use maps were prepared using the shape files gained from the Survey Department. Data was only available for two years. The Slope map was prepared using the DEM (Digital Elevation Map) layer in Arc GIS application. Road networks and railway stations were considered for the accessibility. Road layers were considered for two years. Initial layer in 1987 and the road network changes of main roads in 1996.

Table 02: Data and data sources

Data	Type of Data	Source
Land use maps (1987 & 2010)	Shape files	Survey Department of Sri Lanka
Population data	Shape files	Department of Census and Statistics
Road and Railway Network	Shape files	Survey Department of Sri Lanka Road Development Authority of Sri Lanka
Elevation data	Shape files	Survey Department of Sri Lanka

Macro Model Data

Overall demand for functional land uses in 1987 and 2010 were defined in the model at the beginning as to indicate whether those land uses increase or decrease. Cell counts for each land use for both 1987 and 2010 were obtained from respective land use maps. The growth was considered as a linear growth and cell count for all the functional land use categories were increased during the above period.

Table 03: Macro model data set preparation

Land Use Category	Cell Count (1987)	Cell Count (2010)	1980- 2010 (+/-) %
Highly urbanized	14675	15000	2.21
Moderately urbanized	11093	16497	48.72
Less urbanized	25962	31705	22.12
Very less urbanized	48825	50471	3.37
Paddy	61495	63644	3.49
Marsh	3456	3543	2.52

Results and Discussion

The model was calibrated by taking 1987 as the base year and for the period of 1987-2010. The model was calibrated by 20 occasions to achieve the satisfied level.

Contingency table

Contingency table details the cross distribution of categories on the two maps selected. The table 4 is expressed in number of cells.

Table 04: Contingency table for land use map of 1987(Vertical) and 2010 (Horizontal)

	Other Crops	Highly Urbanized	Moderately Urbanized	Less Urbanized	Very Less Urbanized	Paddy	Marsh	Total
Other Crops	110888	1739	1834	4651	11017	22989	126	153244
Highly Urbanized	2414	8871	2018	509	148	640	75	14675
Moderately Urbanized	2253	615	5777	1392	322	734	0	11093
Less Urbanized	6005	776	2270	12631	1871	2400	9	25962
Very Less Urbanized	13300	537	707	4741	26753	2787	0	48825
Paddy	2832	2358	3840	7769	10315	34086	295	61495
Marsh	198	104	51	12	45	8	3038	3456
Total	137890	15000	16497	31705	50471	63644	3543	

According to the results, it clearly shows that highly urbanized lands have been converted into other land uses although the rule was given to prevent that. But most of the highly urbanized lands have remained the same. Other land use categories also show this same pattern. Marsh has been correctly simulated to a considerable degree converting in fewer amounts into any other land use.

Kappa Statistics

Kappa is the measure of agreement between the two categorical maps. It is less than or equal to 1. A value of 1 indicates perfect agreement and values less than 1 indicate less than perfect agreement. This can be interpreted as follows (table 05):

Table 05: Defining kappa measure -agreement and values

Agreement	Value range
Poor agreement	Less than 0.20
Fair agreement	0.20 to 0.40
Moderate agreement	0.40 to 0.60
Good agreement	0.60 to 0.80
Very good agreement	0.80 to 1.00

Kappa for this model map is 0.467 which is a moderate agreement. It should be more than 0.8 to be a very good agreement. But these results indicate that the modeled map has a moderate level of agreement to the original map (table 06).

Table 06: Kappa values for simulated maps

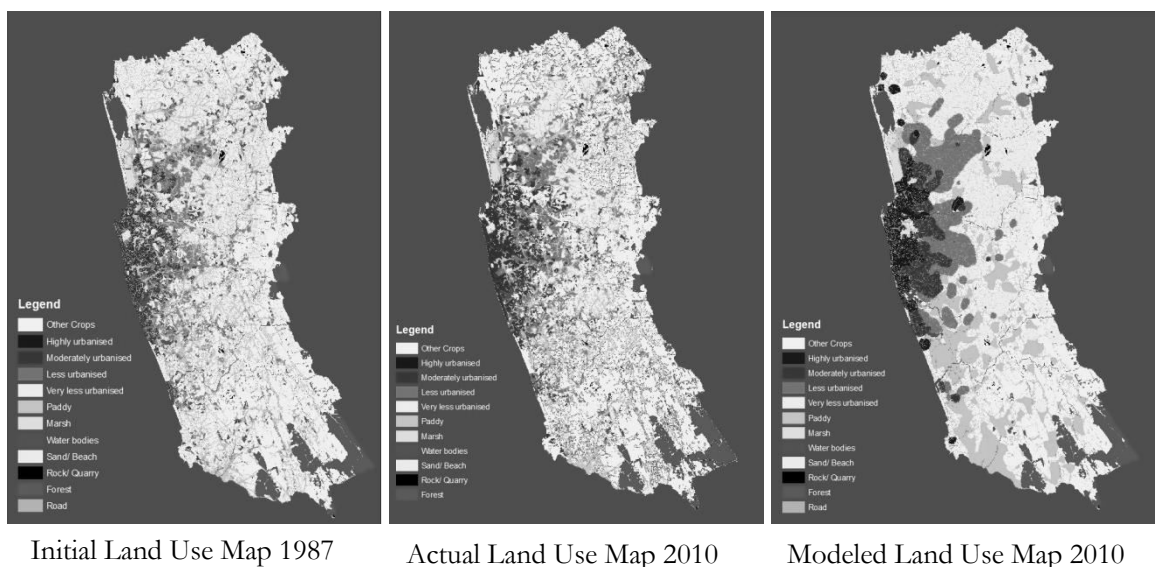
Land Use / cell states	Highly Urbanized	Moderately Urbanized	Less Urbanized	Very Less Urbanized	Paddy	Marsh
Kappa values	0.427	0.255	0.297	0.393	0.403	0.815

Kappa of individual land use categories indicates a very good agreement of marsh which is 0.815. Paddy and Highly urbanized land use are under a moderate agreement and moderate and less urbanized land uses are within fair agreement.

Visual Interpretation

Visual comparison is recognized as one of the suitable methods used in the calibration process. Changes which have been occurred during the years can be observed visually which gives a clear idea of how different land uses have been changed or distributed over the years. For the visual comparison, three maps were used; Initial land use map of 1987, 2010 Land use map, and Modeled 2010 land use map.

Figure 04: Visual representation of actual maps (1987 and 2010) and simulated map 2010



In considering the differences between the actual land use map of 2010 and the modeled map of 2010, it displays the number of overlapping cells in both maps.

Table 07: Analysis of the simulation results with global measure

Land Use Category	Cell count in 2010 Actual Map	No of cells in Both 2010 modeled map and 2010 Actual map	No of cells in modeled 2010 map which not overlapping with 2010 Actual map	Level of Accuracy (Percentage)
Highly Urbanized	15000	6745	8255	44.97
Moderately Urbanized	16497	4752	11745	28.81
Less Urbanized	31705	11313	20392	35.68
Very Less Urbanized	50471	23980	26491	47.51
Paddy	63644	32081	31563	50.41
Marsh	3543	2892	651	81.63

According to the comparison, it clearly shows that the model has been capable to generate the patterns of marsh land to a higher extent which is 81.63 percent. Among urban categories, very less urbanized (47.51%) land use is the most correctly simulated land use and secondly the highly urbanized land (44.97%). Paddy also has been simulated with more than 50 percent of accuracy. But the model has not been capable of generating patterns in urbanized land uses with a higher level of accuracy.

Table 08: Map comparison (1987 with actual 2010 Map)

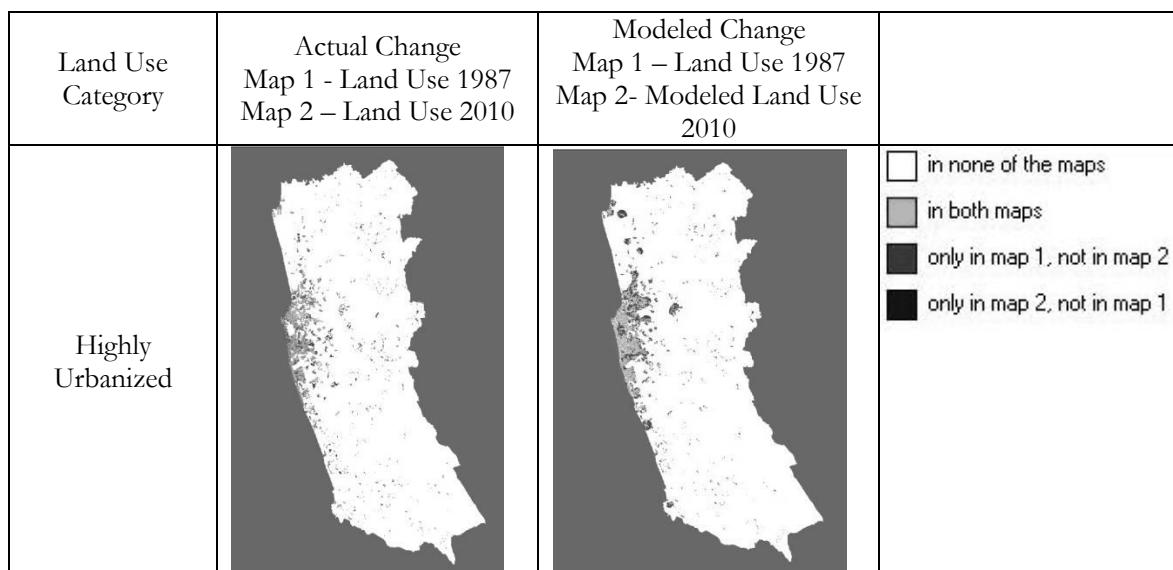
Land Use Category	In both Maps	Only in map 1 (1987)	Only in Map 2 (actual 2010)
Highly Urbanized	10254	4421	4746
Moderately Urbanized	6471	4622	10026
Less Urbanized	18356	7606	13349
Very Less Urbanized	40216	8609	10255
Paddy	56412	5083	7232
Marsh	3239	217	304








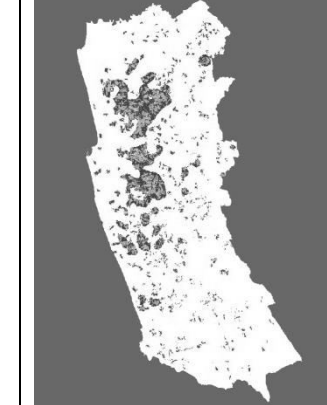





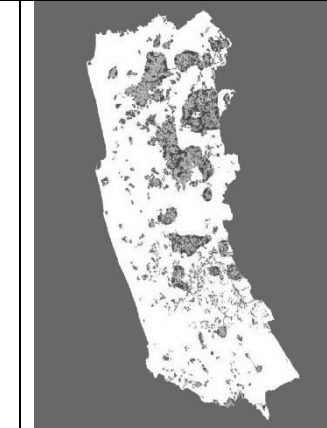





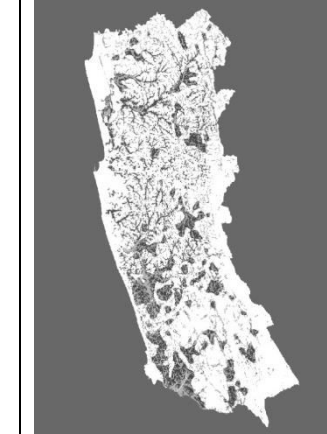




Table 09: Map comparison (1987 with modeled 2010 Map)

Land Use Category	In both Maps	Only in map 1 (1987)	Only in Map 2 (Modeled 2010)
Highly Urbanized	8871	5804	6129
Moderately Urbanized	5777	5316	10720
Less Urbanized	12631	13331	19074
Very Less Urbanized	26753	22072	23718
Paddy	34086	27409	29558
Marsh	3038	418	505

The comparison between the 1987 land use map with the actual land use map of 2010 and the modeled map of 2010 shows how the land uses appeared and disappeared within the region and how land uses have been changed. It also shows to what level the modeled map has been capable to simulate the change between two years.

Figure 05: Comparing the actual change and model change from 1987- 2010 for selected land use categories



Moderately Urbanized			<ul style="list-style-type: none">  in none of the maps  in both maps  only in map 1, not in map 2  only in map 2, not in map 1
Less Urbanized			<ul style="list-style-type: none">  in none of the maps  in both maps  only in map 1, not in map 2  only in map 2, not in map 1
Very Less Urbanized			<ul style="list-style-type: none">  in none of the maps  in both maps  only in map 1, not in map 2  only in map 2, not in map 1
Paddy			<ul style="list-style-type: none">  in none of the maps  in both maps  only in map 1, not in map 2  only in map 2, not in map 1



These calibration results show that the model has been capable of modeling marsh lands with a great level of accuracy. In the modeled map, land uses have been concentrated in many places and the small patches have been disappeared.

According to the analysis, the model has been successful in capturing the dynamics of marsh lands up to 81.63. Although the main focus of the model was to capture the dynamics of urban land uses, the model didn't show a considerable result. This may be mainly due to the neighborhood rules which were not implemented correctly. For this study, urban land uses were categorized according to the population density. This may be caused for this result as these neighborhood rules were not capable of capturing the dynamics of population density distribution.

Conclusions

The findings of the study has indicated the possibilities of employing this model as a potential tool in simulating urban land uses in Sri Lanka. It is found that model had simulated the changing pattern of marshy lands with a high level of accuracy. Simulations of highly urbanized and less urbanized land uses also showed relatively higher levels of accuracy of nearly 50%. More importantly, this modeling exercise opened up further avenues to explore further on land use dynamics and to investigate the validity of the results obtained from a simulation of this nature and the contingencies involved in it.

Despite the promising results of the application of the model, there is significant space for further improvements and customization of the tool in the decision making process. It is understood that the number of calibrations needs to be increased by changing the basic parameter values of the neighborhood rules.

As Byrne (1997) stated, the simulation is clearly a tool which helps us not to know what will happen, but what can be made to happen. In this manner, this will be a very useful tool for planning decision makers as it can handle dynamic factors and visualize those changes, which will be instrumental towards making better informed decisions. However, the constraints related to technicalities and the information sourcing need to be addressed in future applications of the model.

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Application of ArcGIS Model Builder and Python Scripting for urban Flood Modeling

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Abstract

Accurate projection of flood extents in urban catchments has become a challenging task. Accurate data on inundation is useful for identifying flood risk areas and developing flood management strategies to mitigate the negative consequences. Owing to high costs of sophisticated flood simulation modeling software, currently, the required flood data for different studies and projects in Sri Lanka is collected through gauging stations, GPS devices and participatory based mapping approaches. However, these methods are highly time consuming and limited in accuracy. Hence, this paper presents an integrated model that simulates flood prone areas, flood levels and flood water accumulation time in urban areas using ArcGIS model builder and Python scripting. The model was calibrated and validated considering part of the urbanized area beside Kelani River. The results indicated that there is a high level of consistency between the observed and simulated results. Accordingly, the model presented in this paper can be used to simulate the flood inundation information in urban areas in a relatively fast, inexpensive and accurate manner.

Key words: Flood Model, Arc-GIS, Python Scripting, Simulation

1.0 Background

A flood is defined as the inundation of an area by an unexpected rise of water because of extreme rainfalls or dam failure (Disaster Management Center). As shown in Figure 1, it is the most frequent climate exacerbated disaster in Sri Lanka.

In Sri Lanka, most of the flood management approaches are based on hydrological measurements. However hydrology based flood management approaches are most suitable for large scale flood prone areas. Since most of our urban flood prone areas are small in scale, hydrology based flood assessment is inadequate to get a reliable result on flooding conditions of that area. Hence it is vital to consider about the other integrated factors which influence for flood, when assessing the flood condition in small scale urbanized areas. Hence, the objective of this research is to develop an integrated flood model considering the factors such as land cover, rainfall, abstraction levels, elevation, soil types and impervious areas.

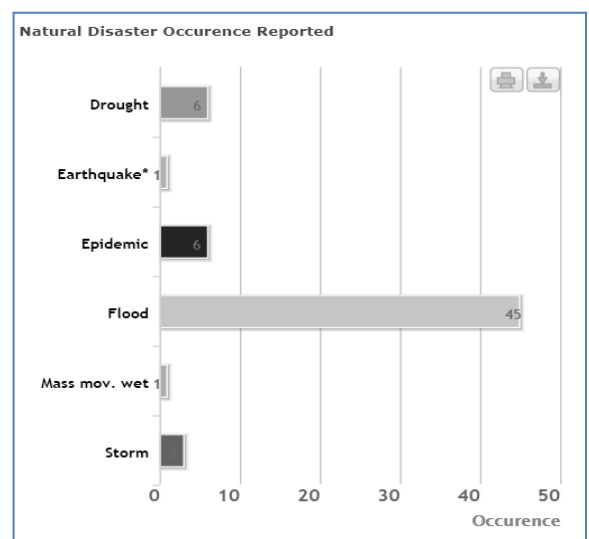


Figure 13: Natural disaster occurrence during the past decade

Source: Disaster Management Center, 2005

2.0 Research Problem

Information about flood estimation is the prime data which needs for developing any flood related plan, project, strategy or research. Before developing flood risk management strategies for any flood prone area, a vulnerability and

disaster risk assessment will be conducted for that area. Such assessment is important for identifying hazard areas and elements at risk. The relevant strategies and action projects are decided for the flood prone area based on those results. Thus, preparation of vulnerability and disaster risk assessment requires accurate flood estimations of the flood prone area to identify the areas with high, moderate and low risk.

However, due to the high cost of sophisticated software used in flood simulation, flood estimation data in Sri Lanka is currently obtained through gauging stations, GPS devices and participatory based mapping approaches. In Sri Lanka, gauging stations are available only for several main water bodies. Hence, flood estimations collected via gauging stations are frequently inadequate to estimate the floods levels of the entire flood prone area. GPS based flood estimations always require ample coordinates and flood levels of the inundation locations. Most of the time, the relevant records are collected from the community of the area. Hence, that method is less accurate. The third method of participatory based mapping approaches always relies on people's perceptions. Hence, that method also has varying accuracy levels.

In addition to that, there are various commercially developed software for flood simulation. Most of the time they are high in cost and need vast amounts of input data to get a relatively accurate result. In some cases, the results produced by them are not represent the real ground context of our country.

Therefore it is essential to have a proper method to simulate flood inundation information in a relatively fast, inexpensive and accurate manner for urban catchment areas of Sri Lanka.

3.0 Objectives

The main objective of this research is to develop an integrated model using Arc-GIS Model Builder and Python Scripting to simulate flood inundation information in urban catchments. The sub-objectives of the research are,

- To simulate inundation areas
- To simulate inundation depth (flood level)
- To simulate the flood water accumulation time

4.0 Flood Estimation Methods

Flood estimation methods can be mainly classified as direct methods and indirect methods.

4.1 Direct Methods

Under direct methods, flood estimations are collected through measurements

4.1.1 Measurements based on current meter

A current meter is oceanographic device which measures the volume of water discharge in a unit time.

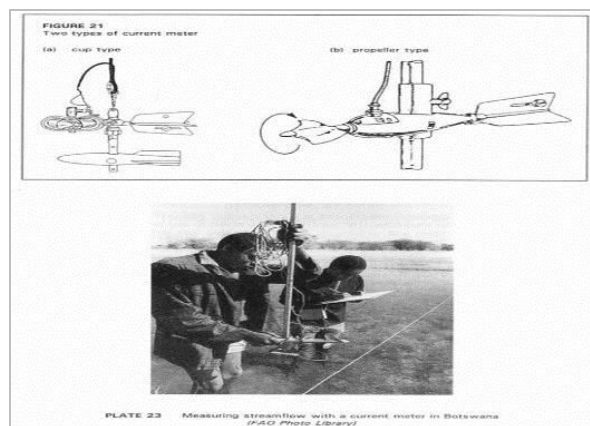


Figure 14: Measurements based on Current Meter

4.1.2 Measurements based on gauging heights

A Gauge Height is a measuring device used to determine the height of water in streams. In Sri Lanka, the Irrigation Department has established 35, 10 and 24 Gauge Heights to measure the water levels of streams in Wet Zone, Intermediate Zone and Dry Zone respectively. However information provided by them are inadequate to estimate the overall flood levels spatially for the entire flood prone area.

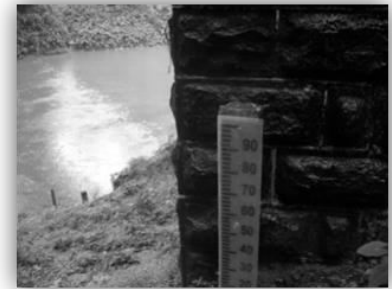


Figure 15: Measurements based on Gauging Stations

4.1.3 Measurements based on GPS devices

Another, recently developed direct method of measuring flood levels is use of GPS (Global Positioning System). Using the GPS devices, coordinates of the inundation locations and the flood levels are recorded. These data are usually obtain from the community of the area. Then the data are exported to GIS software to estimate the flood levels of the entire area. However this method is highly time consuming and needs large number of GPS points to accurately estimate the flood levels of the entire area.



Figure 16: Measurements based on GPS Devices

4.1.4 Measurements based on participatory mapping

Under this method, the community of the area is asked to mark the flood prone areas on the paper maps. The information in the maps are digitized so that it can be analyzed and visualized using GIS. However, the flood levels and areas drawn in the maps can be considered qualitative data, since they are based on people's knowledge, opinions and perceptions. Most of the time, the locations and boundaries of the areas that people draw on the community maps have varying accuracy levels. This is the main drawback of this method.



Figure 17: Measurements based on participatory mapping approaches

4.2 Indirect Methods

Under indirect methods, flood estimations are collected through equations and modeling.

4.2.1 Rational Method

The Rational Method is the most commonly used method of determining peak discharge from small drainage areas. Peak discharge is the greatest amount of runoff coming out of the watershed at any time. The Rational Method is expressed in Equation 1.

Equation 1

$$Q = CIA$$

Where;

- Q = Peak discharge (m³/s)
- C = Rational method runoff coefficient
- I = Rainfall intensity, mm/hour
- A = Catchment area (ha)

The rainfall intensity is the height of the water layer covering the ground in a period of time. The runoff coefficient (C) is a dimensionless coefficient relating the amount of runoff to the amount of precipitation received. It is a larger value for areas with low infiltration and high runoff (pavements, steep gradients), and a lower one for permeable, well vegetated areas (forest, flat land). Table 1 shows the values of the runoff coefficient for different land uses.

Table 8: Values of Runoff Coefficient (C) for Rational Formula

Land Use	C	Land Use	C
Business		Lawns	
Downtown areas	0.70 – 0.95	Sandy soil, flat, 2%	0.05 – 0.10
Neighborhood area	0.50 – 0.70	Sandy soil, avg., 2-7%	0.10 – 0.15
		Sandy soil, steep, 7%	0.15 – 0.20
		Heavy soil, flat, 2%	0.13 – 0.17
		Heavy soil, avg., 2-7%	0.18 – 0.22
		Heavy soil, steep, 7%	0.25 – 0.35
Residential		Agricultural land	
Single family areas	0.30 – 0.50	Bare packed soil	
Multi units, detached	0.40 – 0.60	▪ Smooth	0.30 – 0.60
Multi units, attached	0.60 – 0.75	▪ Rough	0.20 – 0.50
Suburban	0.25 – 0.40	Cultivated rows	
		▪ Heavy soil, no crop	0.30 – 0.60
		▪ Heavy soil, with crop	0.20 – 0.50
		▪ Sandy soil, no crop	0.20 – 0.40
		▪ Sandy soil, with crop	0.10 – 0.25
		Pasture	
		▪ Heavy soil	0.15 – 0.45
		▪ Sandy soil	0.05 – 0.25
		Woodlands	0.05 – 0.25
Industrial		Streets	
Light areas	0.50 – 0.80	Asphaltic	0.70 – 0.95
Heavy areas	0.60 – 0.90	Concrete	0.80 – 0.95
		Brick	0.70 – 0.85
Parks, cemeteries	0.10 – 0.25	Unimproved areas	0.10 – 0.30
Playgrounds	0.20 – 0.35	Drives and walks	0.75 – 0.85
Railroad yard areas	0.20 – 0.40	Roofs	0.75 – 0.95

4.2.2 TR-55 Runoff Equation

Technical Release 55 (TR-55) presents simplified procedures for estimating runoff and peak discharges in small watersheds. These procedures are applicable to small watersheds, especially urbanizing watersheds. The TR-55 equation is as follows:

Equation 2

$$Q = \frac{(P - I_a)^2}{P - I_a + S}$$

Where;

Q = Depth of runoff (in)

P = Rainfall (mm)

I_a = Initial abstraction (in)

S = Potential maximum retention after runoff begins (in)

Initial abstraction (*I_a*) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. *I_a* is highly variable but generally correlates with soil and land cover parameters. Through studies of many small agricultural watersheds, *I_a* was found to be approximated by the following empirical equation:

Equation 3

$$I_a = 0.2S$$

By removing I_a as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting equation 3 into equation 2 gives:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

S is related to the soil and cover conditions of the watershed through the CN (Curve Number). Mass rainfall is converted to mass runoff by using a runoff curve number (Figure 6).

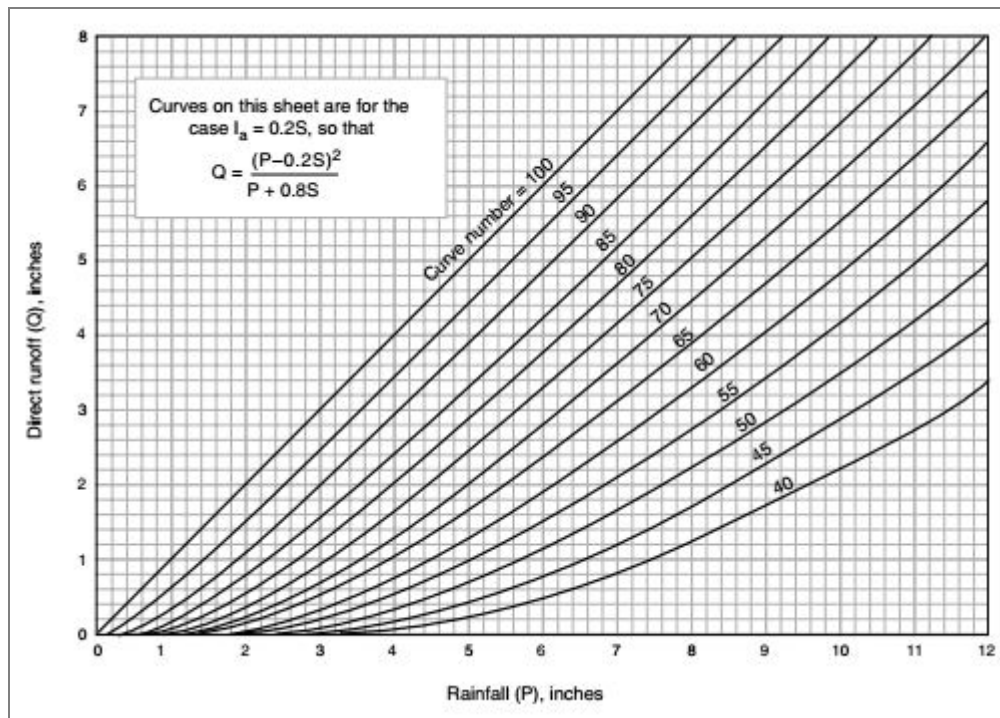


Figure 18: Runoff Curve Numbers (CNs)

S is related to CN by:

Equation 4

$$S = \frac{1000}{CN} - 10$$

CN is based on soils, plant cover, amount of impervious areas, interception, and surface storage. Accordingly, Table 2 shows the computed CNs for different land cover types based on the soil categories.

Table 9: Curve Numbers for urban areas

Land cover type	Curve Numbers for soil types			
	A	B	C	D
Open space (lawns, parks, golf courses, cemeteries, etc.)				
▪ Poor condition (grass cover < 50%)	68	79	86	89
▪ Fair condition (grass cover 50% to 75%)	49	69	79	84
▪ Good condition (grass cover > 75%)	39	61	74	80
Impervious areas				
▪ Paved parking lots, roofs, driveways, etc. (excluding right of way)	98	98	98	98

<ul style="list-style-type: none"> ▪ Streets and roads <ul style="list-style-type: none"> ○ Paved; curbs and storm sewers (including right of way) ○ Paved; open ditches (including right of way) ○ Gravel (including right of way) ○ Dirt (including right of way) 	98	98	98	98
Urban districts <ul style="list-style-type: none"> ▪ Commercial and business ▪ Industrial 	89	92	94	95
Residential districts by average lot size <ul style="list-style-type: none"> ▪ 1/8 acre or less ▪ 1/4 acre ▪ 1/3 acre ▪ 1/2 acre ▪ 1 acre ▪ 2 acres 	77	85	90	92
	61	75	83	87
	57	72	81	86
	54	70	80	85
	51	68	79	84
	46	65	77	82

A – Sand, loamy sand, or sandy loam

B - Silt loam or loam

C – Sandy clay loam

D – Clay loam, silty clay loam, sandy clay, silty clay or clay

4.2.3 Terminal Velocity Formula

The Terminal Velocity formula can be used to measure the velocity of the flood water.

Equation 5

$$V_t = \sqrt{\frac{2mg}{\rho AC_d}}$$

Where;

V_t –Terminal Velocity

m – Mass of the considered fluid section

g - force of the moving direction

C_d - Drag coefficient

ρ - Density of fluid

A – projected area

4.2.4 Flood Modeling

A model is a simplified version of a real world process, system, phenomenon, or entity. Flood modeling helps to predict flood routing patterns using software. Flood modeling is very important to identify flood prone areas, flood levels, velocity of flood flow and flood accumulation time.

An integrated model is a model where various factors or aspects are combined, rather than considering them in a fragmented way. There are several factors that influence urban flooding. They are,

- Rain fall
 - This is the main factor that influence flooding
 - Flood is a common incidence in Sri Lanka, especially in the monsoonal periods. Out of two monsoon periods; South Western monsoon and North Eastern monsoon, South Western monsoon brings the heavy flood for Western Province.

- Terrain/Slope
 - This factor deals with flood routing which is also known as pattern of floods.
 - If a stream has a steep slope, it will have a faster velocity. When the water can't maintain its high velocity in the areas which have gentle slope, there is a probability of flood occurrence at the fringe areas of mountainous zones and intermediate plain zones during the rainy seasons.
- Hydrology
 - This factor also deals with flood routing.
 - When rivers have several bends, velocity of water is decreased. Otherwise river will overflow and create floods. This is the reason for floods in Rathnapura area.
 - Human intervention on hydrological patterns such as land filling and rerouting rivers can also trigger floods.
 - In urbanized areas, because of land paving, infiltration level of land is decreased and creates flood.
- Soil Type
 - Different soil types have different saturation levels.
 - The Wet Zone of Sri Lanka is mainly covered by Red Yellow Podzolic soil which has low saturation level. This character is one of the reasons for high runoff in Western Province.
- Land cover/Land Use
 - Different land cover types have different infiltration capacities. For an example grassland and forest covers have high water infiltration levels while asphalt surfaces have low infiltration level.
 - High surface water runoff can be seen in land covers with low infiltration level.
- Drainage system/Existing storm water discharge system
 - Drainage systems are also an important factor to mitigate floods.
 - Areas with proper drainage systems can manage storm water run-off even at higher level of rainfall.
 - For better flood management, the drainage systems must be well maintained and they should be designed according to the surface water runoff volume
- Human Behavior
 - To certain extent, human behavior also influences flooding. Lack of maintenance of canals, unauthorized land filling and filling of low lands are some of activities which lead for generating floods.
 - In addition to that, the community of the area should aware about hydrological cycles to respond in any flood events.

5.0 Arc-GIS Model Builder and Python Scripting

Arc-GIS is a Geographic Information System (GIS) which facilitates working with maps and geographic information produced by a company called Esri. The Model Builder is an application in the Arc-GIS software to create, edit and manage models. Model Builder can also be thought of as a visual programming language for building workflows. Most importantly, it provides a graphical interface for making models and visually understanding how GIS modeling works.

Python is a free, cross-platform, open-source programming language that is both powerful and easy to learn. Its design philosophy emphasizes code readability, and its syntax allows programmers to express concepts in fewer lines of code than would be possible in languages such as C++ or Java.

Python was introduced to the ArcGIS community at version 9.0. Since then, it has been accepted as the scripting language of choice for geoprocessing. The language is widely used to perform advanced level calculations and raster analysis.

6.0 Case Study

In Sri Lanka, Kalu, Kelani, Gin, Nilwala and Mahaweli are the main river basins vulnerable to floods. Among them, urban floods are more predominant in the Kalu and Kelani river basins. Floods are a frequent disaster in the following areas of those basins:

- Ragamaarea -Gampaha District
- Miriswaththa-Balummahara area -Gampaha District
- Gampaha town -Gampaha District
- Sri Jayawardhanapura Kotte –Colombo District
- Katukurunda Area –Kaluthara District
- Kaluthara town –Kaluthara District
- Waththala, Hekiththa, Wanawasala and Dalugama- Gampaha District

Source: Disaster Management Center/Irrigation Department

The Waththala, Hekiththa, Wanawasala and Dalugama areas which belong to the Kelani River basin were selected as the case study area to develop the urban flood model (Figure 7). In Waththala, Wanawasala and Hekiththa areas, most of the houses which locate at low lying areas are affected during the South Western monsoon due to blocking of canal systems and low level of infiltration due to land filling.

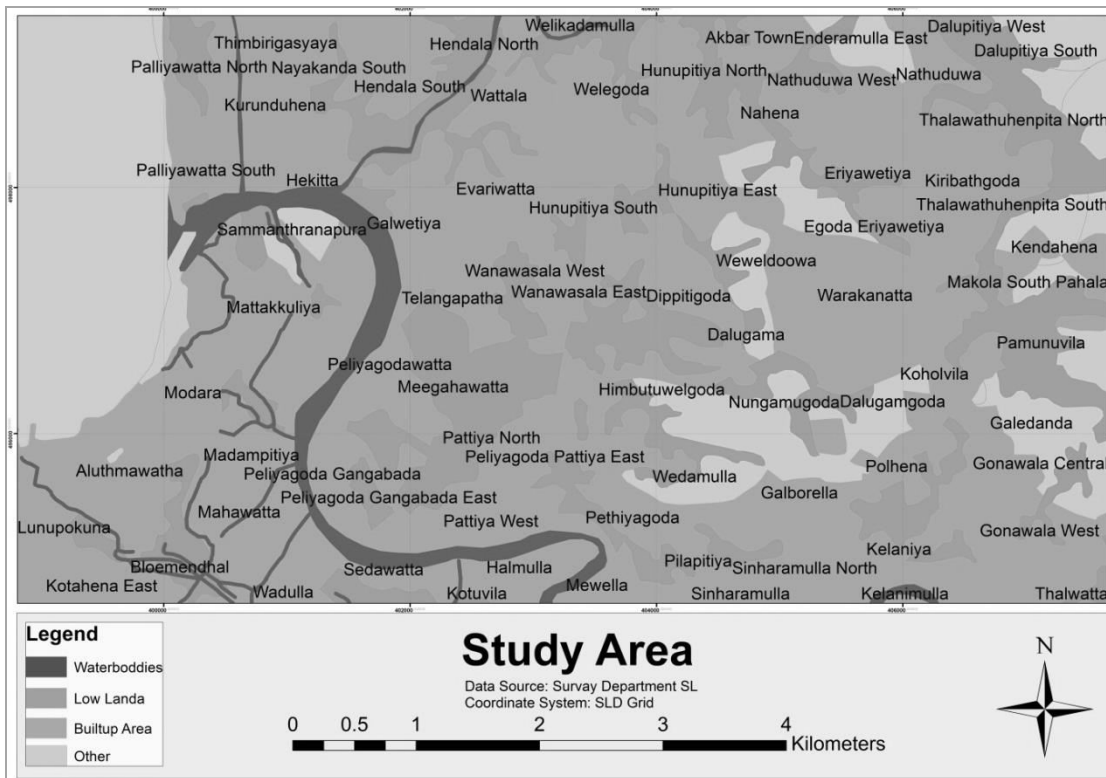


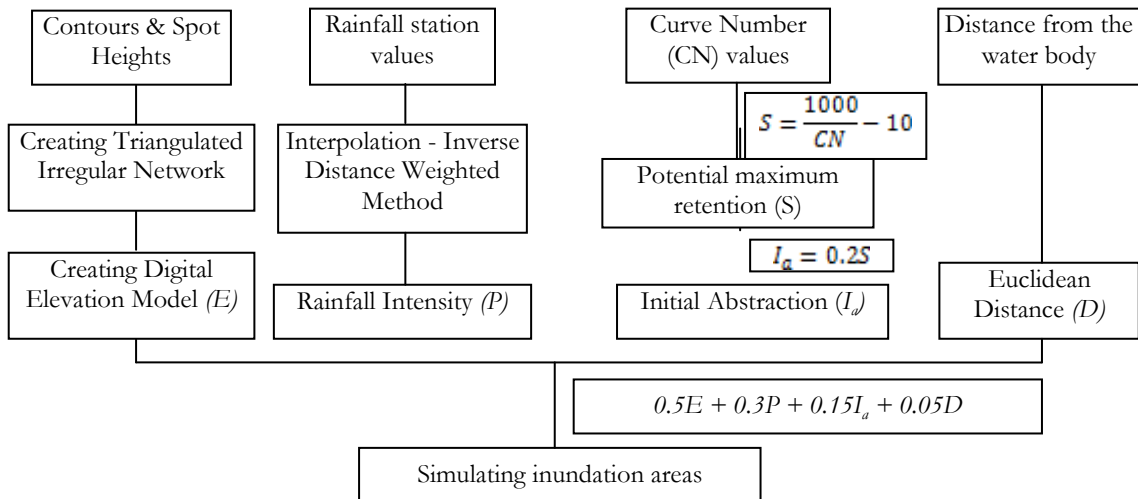
Figure 19: Case Study Area

Sources: Survey Department & Google Earth 2014 Astrim Image

7.0 Methodology & Results

Three models were prepared using Arc-GIS Model Builder and Python scripting to achieve the three objectives of this research.

7.1 Model 1 - Simulating the inundation areas



Assumptions:

1. The coefficient values of the formula were obtained from the research done by *R.Suthakaran, K.Perera and N.Wikramanayake* on "Rainfall intensity-duration-frequency relationship for Colombo region in Sri Lanka"
2. 10m×10m pixel size was considered for the analysis

Table 10: Input Data of Model 1

Input Data	Source
Contours & Spot Heights	Sri Lanka Land Reclamation & Development Corporation
Rainfall station values	Meteorological Department
Soil layer	Survey Department, 2010
Land cover layer	Survey Department, 2010
Curve Number (CN) values	Curve Numbers for urban areas (Table 2)
Water body layer	Survey Department, 2010

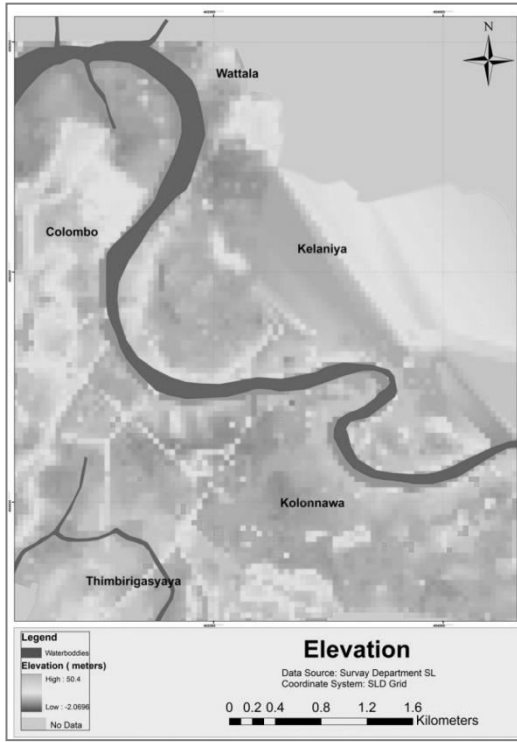


Figure 8: Digital Elevation Model
 Source: Compiled by the Authors

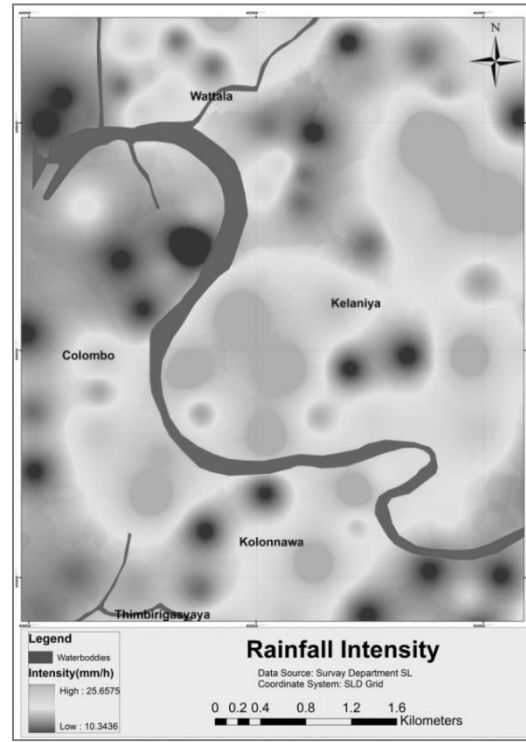


Figure 9: Rainfall Intensity
 Source: Compiled by the Authors

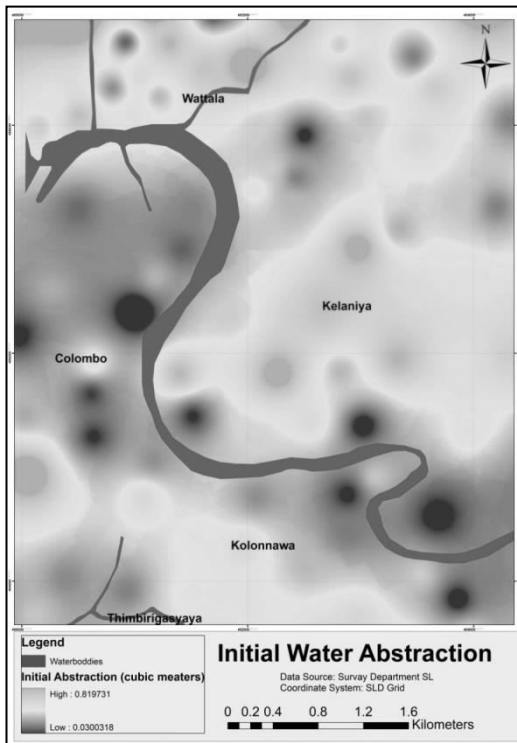


Figure 10: Initial Abstraction Level
 Source: Compiled by the Authors

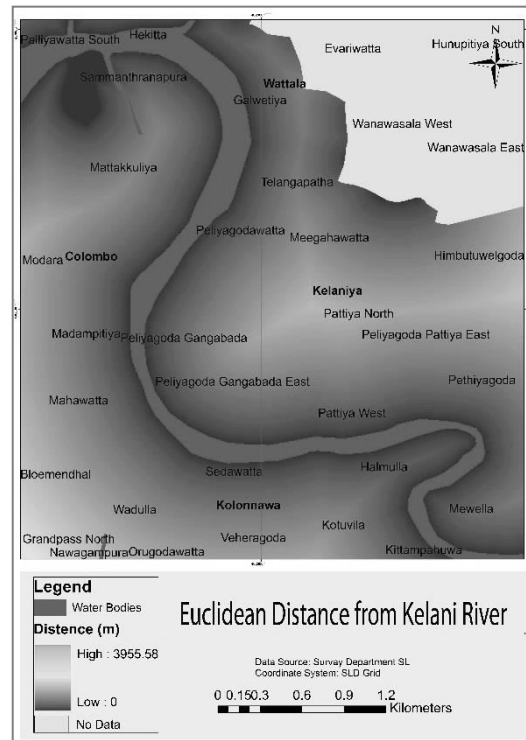


Figure 11: Euclidean Distance from Kelani River
 Source: Compiled by the Authors



Figure 12: Simulated Inundation Area
Source: Compiled by the Authors

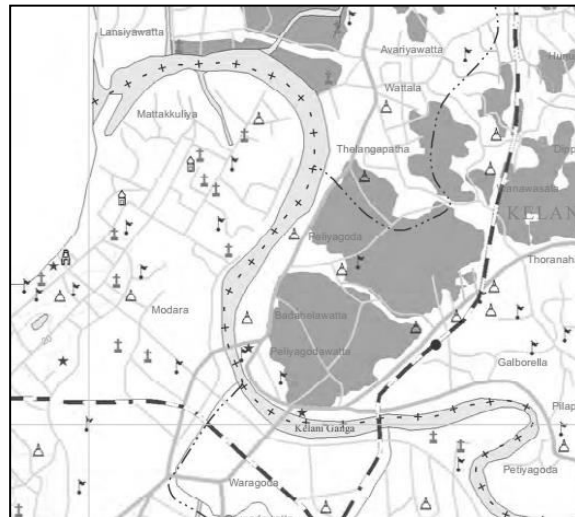


Figure 13: Flood Prone Area map produced by DMC & Irrigation Department
Source: Compiled by the Authors

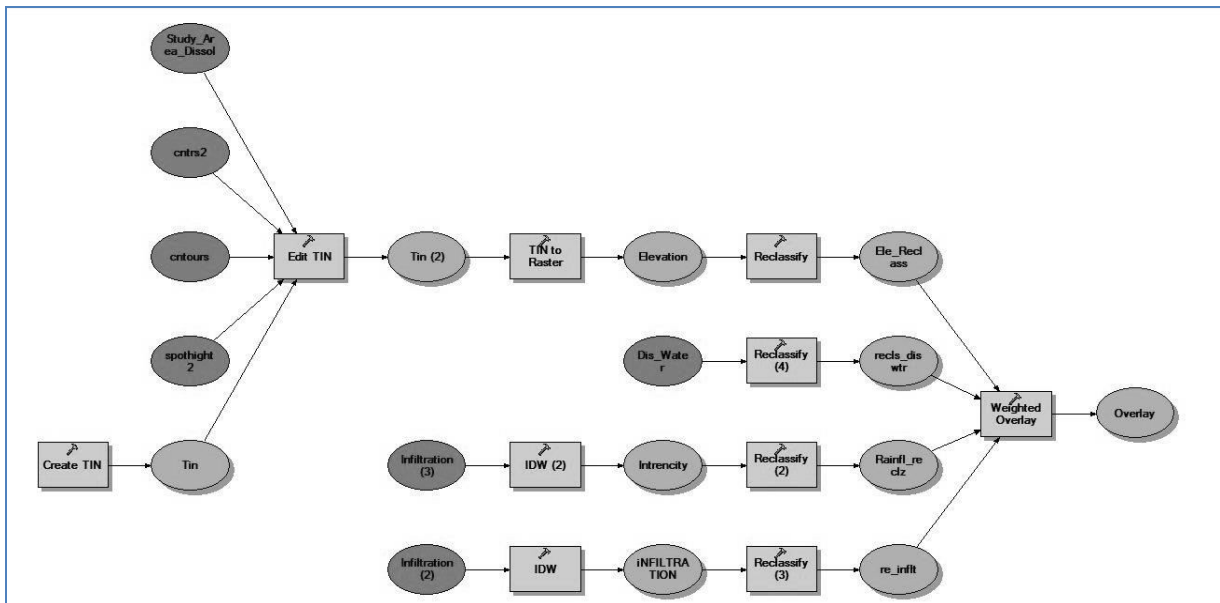
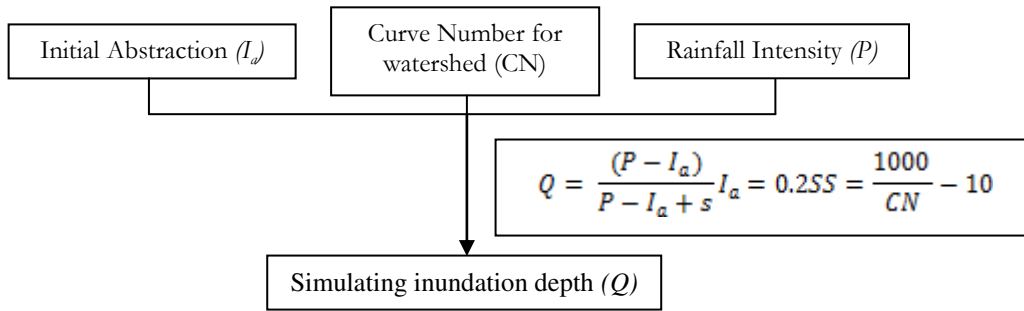


Figure 14: Arc-GIS Model Builder for simulating the inundation areas

Figure 12 shows the inundation areas produced from model 1. Accordingly, the brown colored areas represent the inundation area beside the Kelani River. As depicted in the map Grama Niladhari areas like Sedawaththa and Veheragoda are safe from flooding as they are located closer to the southern bank bund. The results obtained from the model were further validated with the flood map produced by the Disaster Management Center (DMC) and Irrigation Department (Figure 13). Therefore, it seems that the inundation areas shown in the two maps are closely related to each other. Figure 14 shows the screenshot of the Model Builder window of Arc-GIS software which was used to simulate the inundation areas.

7.2 Model 2 - Simulating the inundation depths (flood levels)



Assumption:

1. 10m×10m pixel size was considered for the analysis

Table 11: Input Data of Model 2

Input Data	Source
Initial Abstraction	Obtained from results of Model 1
Curve number for watershed	Curve Numbers for urban area (Table 2)
Rainfall Intensity	Obtained from results of Model 1

Initial Abstraction and Rainfall intensity values were obtained for each pixel based on the results of Model 1. The curve number for the watershed area was obtained from Table 2.

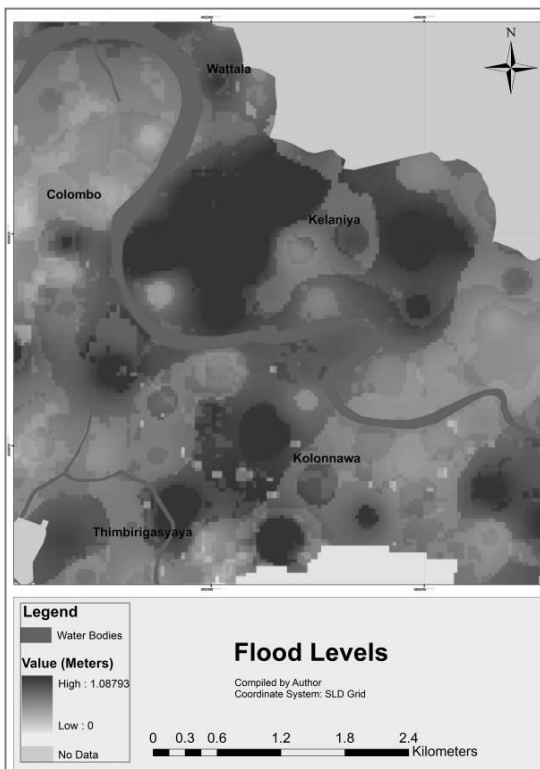


Figure 15: Simulated Inundation Depths
Source: Compiled by the Authors

```

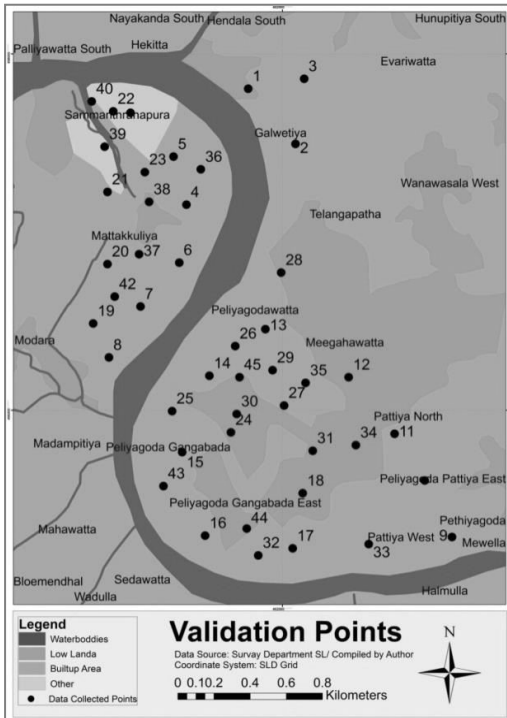
1  from math import *
2  import numpy
3  from osgeo import gdalnumeric
4  from osgeo import gdal
5  from osgeo.gdal_array import *
6  from osgeo.gdalconst import *
7  import sys, string, os, arcgisscripting
8  F = []
9  F.append(E:\Working\Reserch\Intence.tif)
10 F.append(E:\Working\Reserch\Elevation.tif)
11 F.append(E:\Working\Reserch\Infilt.tif)
12 F.append(E:\Working\Reserch\maxretain.tif)
13 driver = gdal.GetDriverByName('ENVI')
14 tmp = gdal.Open( F[0] )
15 geoT = tmp.GetGeoTransform()
16 proj = tmp.GetProjection()
17 del tmp
18 b1 = LoadFile( F[1] )
19 b2 = LoadFile( F[2] )
20 b3 = LoadFile( F[3] )
21 b4 = LoadFile( F[4] )
22 b = [ 0, 0, 0, 0 ]
23 for i in range ( 0, 3 ):
24     b[ i ] = LoadFile( F[ i + 1 ] )
25     lev = ( b1 - b2 ) * ( b1 - b2 ) / ( b1 - b3 + b4 )
26 out = OpenArray( lev )
27 out.SetGeoTransform( geoT )
28 out.SetProjection( proj )
29 driver.CreateCopy( 'E:\Working\Reserch\level', out )
30
    
```

Figure 16: Simulation of inundation depth using Python Scripting
Source: Compiled by the Authors

Figure 15 shows the inundation depths simulated from model 2. The highest simulated flood level of 1.2 m is obtained for Wanawasala, Peliyagoda, Hekiththa & Waththala areas. When validating those results through field observations, the

residents of that area also stated that they received 4-5 feet flood level. Figure 16 shows the screenshot of the Python script which was written to calculate the inundation depth.

The accuracy of the simulated flood levels of the entire inundation area was checked using the "Accuracy Assessment" method. For that several points were randomly selected in the inundation area and the simulated flood levels were crosschecked with the actual flood levels on the ground. Figure 17 shows the randomly selected locations for the validation.



The accuracy assessment method uses the "Kappa coefficient" to test the consistency of the actual values and simulated values.

$$Kappa\ coefficient = \frac{n \sum n_{kk} - \sum n_{k+} n_{+k}}{n^2 - \sum n_{k+} n_{+k}}$$

Where;

n = number of validation points

n_{kk} = difference between actual value and predicted kth value

$n_{k+} n_{+k}$ = difference between sum of actual values and sum of predicted values

Definitions of Kappa Coefficient Values:

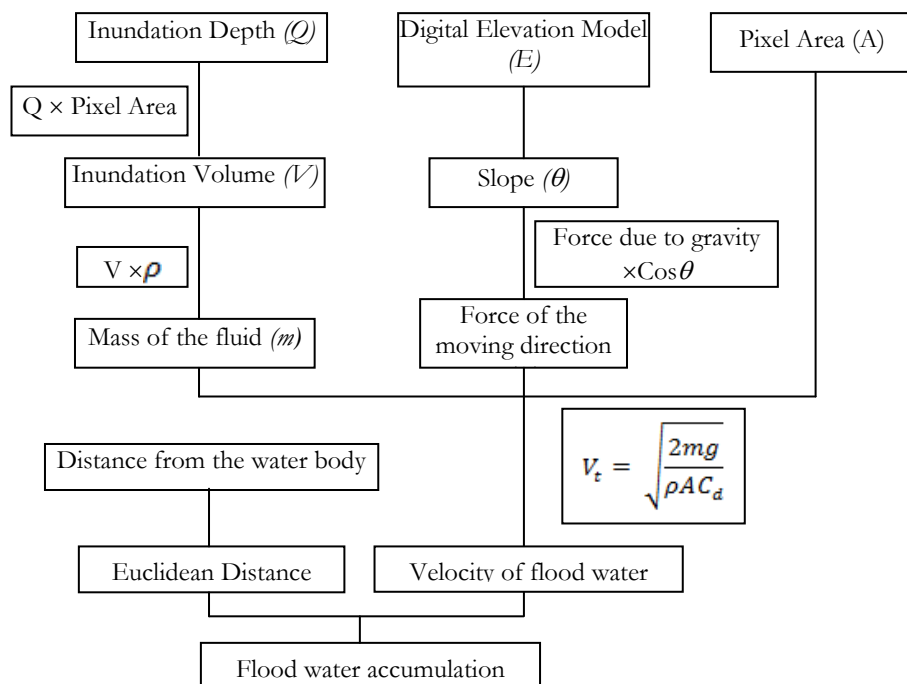
- Poor agreement - less than 0.2
- Faire agreement - 0.2-0.4
- Moderate agreement - 0.4-0.6
- Good Agreement - 0.6-0.8
- Very good agreement - 0.8-1.0

Figure 17: Locations of validation points

Source: Compiled by the Authors

In this validation process the Kappa coefficient was received as 0.7544. Accordingly it can be concluded that there is a "Good Agreement" between the actual values and simulated results.

7.3 Model 3- Simulating the flood water accumulation time



Assumptions:

1. Density of flood water was considered as equal to density of water (ρ)- 1000 kg/m³
2. Force due to gravity was considered as 9.8 N/kg
3. Drag Coefficient (C_d) was considered as equal to entire area - 0.44
4. 10m×10m pixel size was considered for the analysis

Table 12: Input Data of Model 3

Input Data	Source
Inundation Depth (Flood level)	Obtained from results of Model 2
Digital Elevation Model	Obtained from results of Model 1
Pixel Area	Considered as 100m ² (10m×10m)
Distance from the water body	Obtained from results of Model 1

Calculation of flood accumulation time is very essential for studies about floods. However it is rarely used in majority of the studies on flood modeling. Flood Accumulation time is important to execute flood mitigation actions such as activating pumping houses, evacuation planning and opening water outlets.

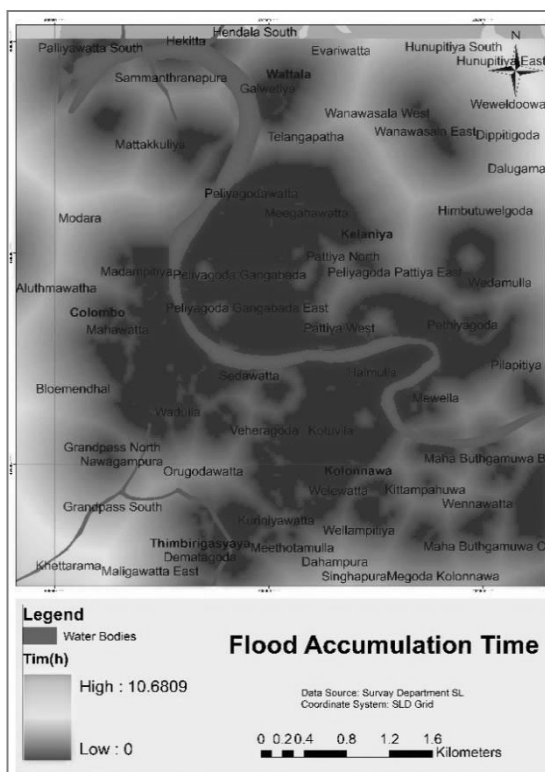


Figure 18: Flood Accumulation Time

Source: Compiled by the Authors

```

1  from math import *
2  import numpy
3  from osgeo import gdalnumeric
4  from osgeo import gdal
5  from osgeo.gdal_array import *
6  from osgeo.gdalconst import *
7  import sys, string, os, arcgisscripting
8  F = []
9  F.append('E:\Working\Reserch\dis.tif')
10 F.append('E:\Working\Reserch\Elevation.tif')
11 F.append('E:\Working\Reserch\Infilt.tif')
12 F.append('E:\Working\Reserch\maxretain.tif')
13 F.append('E:\Working\Reserch\slope.tif')
14 F.append('E:\Working\Reserch\level')
15 driver = gdal.GetDriverByName( 'ENVI' )
16 tmp = gdal.Open( F[0] )
17 geoT = tmp.GetGeoTransform()
18 proj = tmp.GetProjection()
19 b1 = LoadFile( F[1] )
20 b2 = LoadFile( F[2] )
21 b3 = LoadFile( F[3] )
22 b4 = LoadFile( F[4] )
23 b5 = LoadFile( F[5] )
24 b = [ 0, 0, 0, 0 ]
25 for i in range ( 0, 4 ):
26     b[ i ] = LoadFile( F[ i + 1 ] )
27     m = ( b5 - b2 ) * 10000
28     f = m * 10 * cos( b4 )
29     a = f / m
30     r = a * m / sin( b4 )
31     t = ( a - r ) / sin( b4 )
32     v = a * t
33     t1 = b1 / v
34 out = OpenArray( t1 )
35 out.SetGeoTransform( geoT )
36 out.SetProjection( proj )
37 driver.CreateCopy( 'E:\Working\Reserch\time', out )
38

```

Figure 19: Calculation of Flood Accumulation Time using Python Scripting

Figure 18 shows the simulated flood accumulation time of the area beside Kelani River. According to the above map Paliyagoda, Wanawasala, and Waththla has lower flood accumulation time about 1-2 hours. Figure 19 shows the screenshot of the Python script which was written to calculate the flood accumulation time.

The result of this model is also useful to get an idea about the direction of flood with respect to time. For an example Peliyagoda is located in close proximity to Kelani River and Meegahawaththa is located 1.5km away from Kelani River. As flood water accumulation time is proportional to the distance from the Kelani River, Meegahawaththa area should have high accumulation time compared to Peliyagoda. However according to the above figure, Meegahawaththa has less accumulation time compared to Peliyagoda. That result indicates Meegahawaththa area is suffering from floods which

come from Northern side. Therefore the above result is also useful in getting an idea about travelling direction of flood water.

8.0 Conclusion

In this study, three models have been developed using Arc-GIS software and Python scripting to simulate the inundation areas, inundation depths and flood water accumulation times in part of the area in the Kelani River basin. The simulated results, validated through field observations and secondary information indicated that there is a high level of consistency between the observed and simulated results. Hence, the flood modeling approach presented in this research can be considered as an indirect flood estimation method to simulate the flood information of small scale urban catchment areas in an accurate manner. However, the accuracy of the model outputs are solely based on the accuracy and reliability of the input data used in the model. For example, the model needs large scale contour data and cluster of rainfall station values to simulate an accurate result. Pixel size is also a major determinant of deciding the accuracy of simulated outputs. The greater the pixel size, the lesser the accuracy of spatial outputs. On the other hand, low pixel sizes require more detailed information. In this study $10\text{m} \times 10\text{m}$ pixel size was taken for developing the flood model.

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A Study on the Potentil of Rainwater Harvesting Practices to Mitigate Urban Floods

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Abstract

Floods are a prominent issue and the challenge of urban flooding can be turned into an opportunity by adopting rainwater harvesting practices. Rainwater harvesting (RWH) works as a more reliable, cost effective and sustainable way. It is a mean of public contribution to mitigate urban floods rather than provide a supplementary source of water. The catchment area, maximum rainfall intensity, extent of building roofs, potential runoff, and outflow of water and estimated capacity of rainwater system are the highlighted six important factors through the literature. Arc GIS hydrology tools, IDF curves, rational method, the Manning formula and water balance equation were adopted to calculate the above factors. The relationship between capacity of a rainwater harvesting system (y) and the extent of roof area (x) has been derived by an equation of $y=0.024x$. This proposed rainwater harvesting system is potentially applied either in the form of individual building units or as a common water detention pond. This study has focused on identifying an appropriate mechanism to practice rainwater harvesting to mitigate urban floods in Colombo.

Key words: Urban Floods, Run-off Control, Volume of RWH System

1. INTRODUCTION

Floods are a prominent issue caused by increasing impervious surface in the urban environment (Mhonda, 2013). The world disaster report(2011) shows that events of flooding accounted for 47% of all reported natural disaster events in the world in year 2010 and it is believed that the amount and scale of flood events will continuously increase in the next 50 years due to the fast urbanization trend and desirable environmental changes which are attributed to climate change. With changes in global climate and the process of urbanization, the incidence of natural disasters and resultant damage is increasing because of interactions between natural and artificial factors (Barbosa, Fernandes, & David, 2012). Therefore, intense storms in an urban area can cause disastrous flooding and enormous human and economic losses (Zhang and Boazhu, 2006). Numerous strategies have been applied for the prevention of urban floods which includes structural strategies and non-structural strategies (Mhonda, 2013). The problems which are emerging in urban areas constraint to the natural phenomenon. It has caused to need of an involvement of manmade in cooperation to management of storm runoff. The priority of an integrated view of storm water management should have given to the water quality itself meanwhile the erosion and flood control being considered. As expected, Runoff picks up sediments and pollutants in drainages and carries these to receiving water bodies. Effective management is needed at the base point where storm water generated.

Consequently, it is effective to use a source controlling method while tapping the potential of rainfalls. Kim and Han (2008) state that decentralized rainwater tank systems can be a simple and reliable solution to urban floods caused by climate change or urbanization. In the urbanization process, the emerging challenge is control storm runoff in developed built environments with limited space (Dormouth). Rain water harvesting technique can be applied to control floods as a mitigation strategy in the urban context consideration with the rainfall pattern. Rain water harvesting as the best management practice to align with limited space while having economic benefits besides ecological benefits. Since the research is focused on how rainwater harvesting can be integrated to mitigate local floods in site level planning practices in the urban context, as a substitute method for source control to reduce urban flood in the built environment.

2. LITERATURE REVIEW

2.1. Types of floods

Urban floods can be divided into four categories as riverine floods, flash floods, coastal flood and local flood based on different combinations of casual factors and on their impacts (A Tool for Integrated Flood Management, 2008). Concentrated on the local flooding in urban context, it spreads from localized micro-drainage problems, inundating streets and troubling pedestrians and urban traffic due to the inundation of a large part of the city (Miguez & de Magalhães, 2010). Furthermore, these problems lead to material losses in buildings, damages to urban infrastructure, relocating vulnerable people, increasing risk of diseases and deterioration of water quality.

2.2 Causes and impacts of flooding

Hossein, Mehrabadi, & Motevalli (2012) divide the factors that result in flood occurrence into two main categories. The first category is related to urban development and the second to problems caused by improper design of urban drainage structures or mismanagement of surface runoff in cities (Hossein et al., 2012). When heavy rainfall occurs the existing drainage network is unable to support the volume of water overflow and it results in urban flooding. In addition, the intense of flood occurrences, especially in urban areas, are largely due to the urbanization process that results in increase of impervious surface which shortened the time of concentration and increase the magnitude of the runoff discharge (Becker 1998).

Regarding the impacts over urban floods, it disrupts social systems and causes significant economic losses (Petersen, 2001). Among the impacts, there are losses of human and animal lives and health hazards, flooding of housing, commercial and industrial properties, flooding of streets and junctions, causing traffic delays, disruption of services such as water supply, power supply and sewerage (Jha, Bloch, & Lamond, 2011). (Petersen, 2001) explains that flood impacts are evaluated on the extent of inundation in the catchment, velocity of flow, fluctuations of flood levels. Further, he classifies the flood damages as direct and indirect damages, secondary damages and intangible damages. Direct damages are losses due to exposure of property to flood water, including replacing and repairing private property and infrastructure. Indirect damages include the loss of business and services, measures to safeguard health, traffic delays. Secondary damages include adverse impacts on people who depend on output produced by damaged property or services. Intangible damages include impacts on environmental quality, social comfort and aesthetic values.

2.3 Flood mitigating strategies

The concept of flood control has been evolving continuously, accompanying historical demands of urbanization and its consequences (Miguez & de Magalhães, 2010). Mhonda (2013) states there are two main categories of flood mitigating strategies, namely, structural and non-structural. Structural strategies are engineering works (e.g. canalization and rectification, dredging and dike construction). Nonstructural strategies are non-engineering based strategies (loss sharing, disaster aid, flood hazard mapping, flood forecasting and warning, flood risk management, institutional arrangement and preparedness). Walesh (1989) presents two runoff quantity control approaches on mitigating floods which are conveyance oriented approaches including culverts, sewer systems, drainage channels etc. and storage oriented approach including detention, retention, rain water harvesting etc.

Regarding the flood controlling strategies, the storage oriented approach can be identified as a sustainable, more reliable and cost effective strategy than the conventional approach (Walesh, 1989). Since classical drainage design concepts are intensive methods that focus on improving runoff (Petersen, 2001) explains that management of storm runoff is necessary to compensate for possible impacts of impervious surfaces such as increased frequency of flooding. Builders, developers, and engineers can utilize rainwater harvesting systems complying with storm water management regulations. With the increase of land prices and scarcity of land, other storm water management practices like wetlands and wet ponds, become too costly and sometimes even impossible to incorporate into a project (Hunt & Szpir, 2011). Rainwater harvesting systems, being either completely underground or taking up a small amount of space on the perimeter of the catchment zone, help to preserve the natural hydrologic cycle and contribute to low impact development (Hunt & Szpir, 2011).

2.4 Rain water harvesting

Rain water harvesting was used by old civilizations as a drinking water supply and for irrigation purposes, by collecting natural rain storms. Prinz (1996) mentioned that RWH is still in practice in some rural and urban parts of the world and

the recent technologies have gained more attentiveness as effective water conservation and management methods. Hossein, Mehrabadi, and Motevalli (2012) explain that rainwater can be collected from residential buildings, sidewalks, streets and parks by applying various methods. Basinger (2010) states that RWH systems can reduce volume of roof runoff discharged to the drainage. Mahmoud et al. (2014) explains that RWH structures reduce the water velocity during flooding events by increasing the concentration time of the hydrographic basins while reducing the flood peak.

2.5. RWH practices to mitigate urban floods

Kim (2014) has showed the potentials of RWH practices to mitigate local flooding in urban areas by modeling the volume of rainwater storage tanks, considering factors of catchment area, rainfall conditions, design of the rooftop surface and volume of peak outflow of storm water. Hossein, Mehrabadi, and Motevalli (2012) have operated RWH on the roofs of residential buildings to reduce urban floods in Tehran in Iran, considering factors of average annual rainfall, frequency of flood occurrence, area of roofs, coefficient of water runoff and daily demand for water. Petruccia et al (2012) have practiced RWH to control storm water runoff in suburban areas in Paris as an experimental study. The type of the house, rainfalls and extent, slope and the use of land have been taken in to account.

3. METHODOLOGY

The literature highlighted six important factors such as the catchment area, maximum rainfall intensity (frequency of flood occurrence), extent of building roofs, potential runoff, and water outflow and estimated capacity of rainwater system. First, the process of the catchment delineation was run by manipulating DEM, fill, flow direction, flow accumulation, flow length, snap pour points and water shed to identify the flood affected area using Arc GIS hydro tools. Then, determination of maximum rainfall is important to control runoff from the catchments of building roof areas which determine the flood. Using the previous rainfall data, Intensity – Duration - Frequency (IDF) curves were developed for the selected catchment area. For a flood return period of T years, the rainfall intensity (i) is the average rate of rainfall from a storm having duration equal to the time of concentration (t) of the catchment. The average rainfall intensity (i) can be obtained from the Intensity – Duration - Frequency (IDF) curves.

Thirdly, a database was prepared by categorizing the material of roofs and calculating the areas of rooftops. Afterwards, an estimation of peak runoff from the rooftops can be calculated by applying Rationale method. The depth of rainfall of the selected catchment was determined by analyzing meteorological characteristics of rainfall intensity, duration, evaporation and physical characteristics of slope and imperviousness. As the fifth step, the volume of water outflow through drains was calculated applying Manning’s Equation that is a function of the channel velocity, flow area and channel slope. Volume of required RWH systems was calculated using water balance equation developed by Kim (2004). Finally the relationship between the capacity of RWH system (y) and the extent of roof area (x) was derived through simple linear regression analysis.

4. ANALYSIS

As a result of rapid urbanization process, most of the areas in western region in Sri Lanka are vulnerable to flood occurrences. The Wijerama-Horton place junction and the surrounding areas in the Colombo MC were selected as the case study area for the research. Furthermore, this area is highly vulnerable for local flooding once a year, due to the lack of drainage capacity in the area and it has been affected to make heavy traffic jam on the roads and damages on infrastructure. Interviews and field observations were carried out to collect necessary primary data and secondary data was collected through the sources indicated in Table 1.

Table1: Secondary Data collection, type and source

Data	Data Type	Source
Flood inundation Data	Flooding locations, flood depth	SLLRDC/ CMC
Rainfall	Depth of rainfall different return periods	Recent rainfall studies in Colombo district (Suthakaran, Perera, & Wikramanayake, 2014)
Drainage network of selected site	Flow velocity, Diameter of cannels	Metro Colombo Urban development Project
Digitized maps (2010)	Built up area, shape file	Survey Department of Sri Lanka

Step one- Delineation of Catchment

The following method of study was used to delineate the catchment of the case study area as 200.39 ha using Arc GIS 10.1.

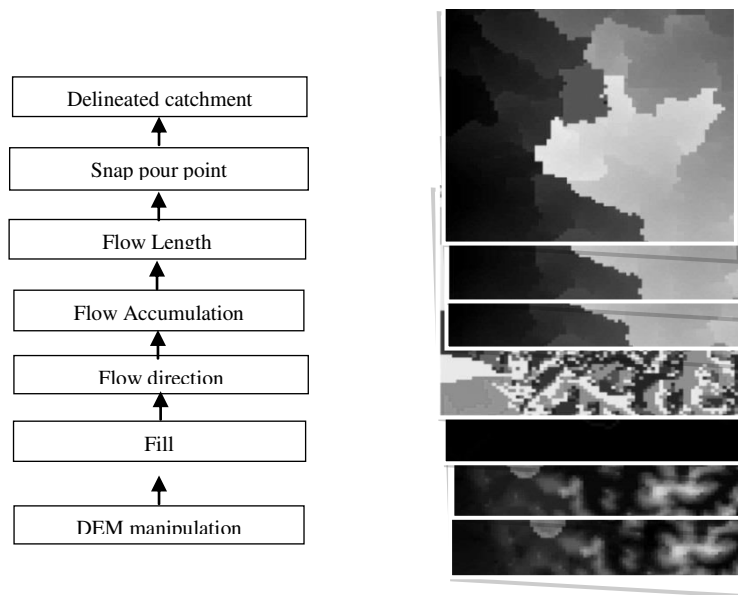


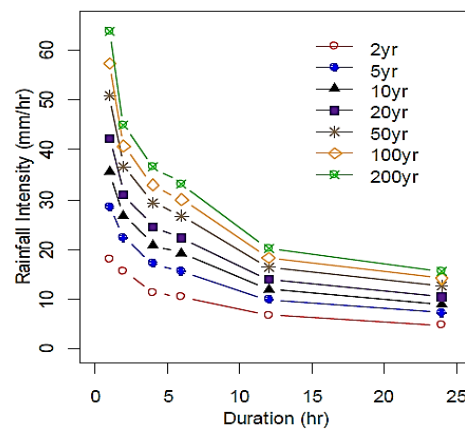
Figure 1: The Process of Catchment Delineation

Step two- Analysis of Rainfall Data

The Metro Colombo urban development project highlighted that the above delineated catchment area was affected by 1 year, 2 year, 10 year and 20 year flood returns. Relationships of the intensity of rain, duration and frequency for each flood return years in the Colombo region was identified by analyzing over 65 years of rainfall data. This study was done considering IDF curve values for one hour rain fall duration of 2 years, 5 years and 10 years of flood return periods.

Table 2: Maximum rainfall intensity at different duration and each return period

Flood Return Periods (years)	Duration (h)					
	1	2	4	6	12	24
2	18.01	15.76	11.42	10.48	6.84	4.95
5	28.53	22.44	17.18	15.70	9.94	7.44
10	35.49	26.86	21.00	19.16	12.00	9.09
20	42.17	31.10	24.66	22.47	13.97	10.67
50	50.82	36.59	29.39	26.76	16.52	12.72
100	57.30	40.70	32.94	29.98	18.43	14.25
200	63.76	44.80	36.48	33.18	20.34	15.78



Source: Relationship of Rainfall Intensity-Duration-Frequency for Colombo Region

Step three-Analyze building roofs

1299 buildings were identified for the study located within the catchment area and majority of them was residential. Type of the constructed material of the roof top of the building was identified through field observation and the area of the rooftop of each building was calculated using digitized maps and field calculator of Arc GIS.

Step four-Potential runoff calculation

Rational method was used to calculate the potential runoff from the building rooftops.

$$Q = C * I * A$$

C= Runoff coefficient (3rd step- types of building roofs)
 I= Rainfall Intensity(2nd step- maximum rainfall mm/h)
 A= Area (3rd step- roof area by m²)

Potential water runoffs were calculated considering the area of each rooftop, rainfall intensity values of 18.01mm, 28.53mm, and 35.49 mm consequently for 2 years, 5 years and 10 years flood return periods. One hour rainfall intensity was used because the IDF curve illustrates the reduction of intensity with the time interval of the rainfalls. The Runoff coefficient values were identified based on the roof types. Accordingly 0.85, 0.82 and 0.50 coefficient values are consequently respect to Asbestos, Tile and Concrete material. Based on the determined values of factors of the rational formula the potential runoffs from each building under each flood return period were calculated. The total runoffs from all buildings in the study area were 9533.33 m³/h, 15101.94m³/h and 18786.12 m³/h with respect to 2 years, 5 years and 10 years rainfall returns.

Step five-Water out flow calculation

The capacity of the respective drain of each buildings is considered as the outflow for the potential runoff generation of each building. Measures relevant to drainage length, diameter of the open channels and slope of channels were obtained from the Report of Metro Colombo Urban development project. Manning’s coefficient of roughness was considered as 0.015 since all drains of the study area have been constructed by using concrete material. Capacity of outflow was calculated using Manning Formula with respect to each building.

$$Q = \frac{1 * (3.118 * 10^{-6}) * (D_3^8) * (S^{1/2})}{n}$$

Where: Q = runoff (m³/s)
 V= velocity
 S= slope of hydraulic gradient (generally slope in SWD)
 D= Internal diameter of pipeline in mm
 n= Manning’s coefficient of roughness

The total outflow capacity of the selected catchment was calculated as 3263.22 m³/h to the total drainage length of 23.14 Km.

Step Six- Estimate volume of RWH system and developing a Simple Linear Regression Model (SLRM)

Appropriate volumes of RWH systems for each building were estimated using the water balance equation on the reduction of outflow from the total inflow starting the rooftop by the following equation.

$$V_{t_i} = \int_{t_0}^{t_i} (Q_{in} - Q_{out} - Q_{Sup}) dt$$

Q_{in} is defined as the volume of water runoff from the roof during one hour. Q_{out} is defined as the volume of water outflow or capacity of the existing drains with respect to each building. Q_{sup} is considered as 0 volume. It was assumed that people are not tendency to use rainwater during the raining period since pipe born water supply is available. V_{t_i} is defined as the volume of the RWH system which can be calculated by integrating the volume of balanced water with comparing to one hour time duration. Proper tank size of the RWH system for each building for preventing 10 years flood return can be categorized in to six categories as indicated in figure 02. If tank volumes can bear the 10 year flood return, it has already achieved the 1 years, 2 years and 5 years flood returns.

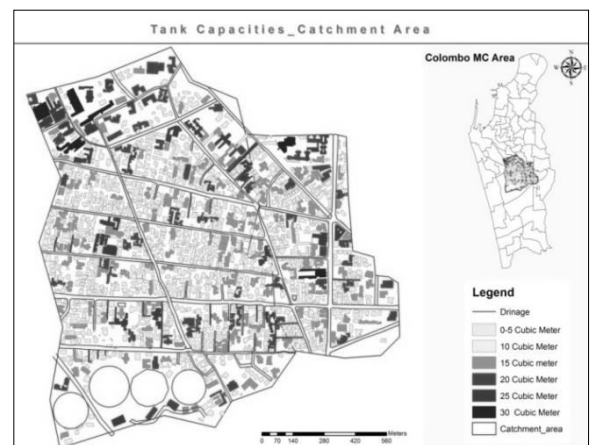


Figure2: distribution of Tank volumes to the buildings Source: Prepared by Author

The relationship between capacity of rainwater harvesting system (y) and the extent of roof area (x) can be derived through SLRM as an equation of y=0.024x (where constant is equal to -7.583E⁻¹¹). R square value of 1.0 indicates that the model is adequate to the context. Data on the estimated volume of RWH system and the extent of roof area of

1299 buildings were used to develop this SLR model using SPSS software. This SLRM can be used to estimate the size of the RWH system when the extent of the roof is known with respect to the future residential or commercial use in the catchment of Wijerama- Horton place junction and surrounding area.

5. CONCLUSIONS

5.1 Findings of the Analysis

According to the flooding locations, the delineated catchment was 200.39 ha including 1299 buildings and it was highly developed residential area. Frequency analysis of the maximum daily rainfall over the period illustrates that 18.01mm/h, 28.53mm/h, 35.45mm/h respect to the 2yr, 5yr and 10 year maximum return of rainfall affected for flooding in Horton place and surrounding area of Colombo. Total potential runoff was calculated as 6298m³, 11884m³, 15580 m³ to the 2years, 5 years and 10 years maximum return. The capacity of the current storm water drainage system of the selected catchment has found as 3264 m³ by applying the Manning formula. Appropriate sizes of RWH systems was decided in to 6 categories to avoid 2, 5 and 10 years return flood in the catchment by 90%. The developed equation of $y=0.024x$ can be used to determine the volume of the RWH system for future residential or commercial use in this area.

5.2 Implication and Contribution

The identified method would be useful to planners, engineers and decision makers who are in search of solutions to address emerging issues on urban flooding in Sri Lanka. Although the rainwater harvesting policy established in 2005 in Sri Lanka it is not much attracted in planning practice since the policy was not interpreted how and which volume RWH system should be established in commercial and residential premises. Furthermore, this developed method will be attractive to the planning practice when providing the building approvals.

5.3 Research Limitations and further research

The study was conceded using the impervious building's rooftops of the area and garden area. It was assumed as there is no considerable runoff at the peak precipitation at the previous areas. This method can be developed toward as a more reliable method by conducting the field surveys. Considering the holistic view of the catchment area, using different RWH methods determine what type of water harvesting method can mitigate local flooding within residential and commercial premises.

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A study on the relationships among *Natami*, city functions and built environment with special reference to Pettah, Sri Lanka

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Abstract

Wholesale and retail trades play a vital role in a city's economy. From the early days of the evolution of cities, a group of labor specialized in loading, unloading and carrying goods emerged to cater to the need of moving goods within the city. During the Colonial era, in order to cater to the demand for economic means of delivering goods within the city in increasing wholesale and retail businesses, the British rulers brought in Indian Coolies to Sri Lanka and to many of their colonies to provide manual labor. Today, they are identified as Natamis and work in wholesale trading areas such as Pettah in Colombo and many other urban areas in Sri Lanka. With the advancement of technology many of the tasks of these goods carriers got replaced by motorized modes such as forklifts, trucks, lorries, cranes etc, but this occupation is not totally disappeared from the wholesale trading areas in Asian cities. It is observed that the character of the built environment and the prevailing city functions, especially the mode of local transactions of goods between traders, support the extended existence of Natami in Pettah; City of Colombo. This research explores the relationships between the Natami community, the city functions and the built environment of the City of Colombo using network analysis. Through the understanding derived from the analysis, this paper calls for the due attention of the policy makers and planners in planning and designing the city environments to identify the hidden but vital role played by these communities in making cities more effective and vibrant.

Keywords: Good Carriers, City functions, Built environment, Network

1. Introduction

Vehicular Traffics, greenhouse gas emission and accidents are some of the frequent topics related to 'Motorized transportation' (MT). Therefore, most of the countries concentrate on 'Non-Motorized transportation' (NMT) modes on their way to sustainable cities. Man power based traditional loading and unloading workers are also one of the NMT modes that expands rapidly in Asian cities. Rather than using motorized modes such as fork lifters/three-wheelers many of the developing countries adopt manpower based traditional loading and unloading modes.

For instance, in Sri Lanka, during the Dutch era, trade and commerce activities were confined to the streets in Pettah. During the British era, with the expansion of the sea port and the associated back yard facilities, the northern parts of Fort and Pettah grew as the high order business district and Colombo attracted people from the other parts of the country. (Munasinghe, 2007) When the Port activities expanded over time, Indian coolies were brought to move the wholesale goods by British as local communities refused to engage in this work. They were called "*Natami*" (*traditional loading and unloading workers in Sri Lanka*).

Although it has passed many years, *Natami* still in Pettah, (the immediate receiver of the wholesale goods from the port) carrying heavy loads on their bare backs or on their hand-pull carts. Although many alternative modes emerged, still *Natami* are surviving in Pettah. Accordingly, the research is to investigate the relationships among *Natami*, the built environment and the city functions of Pettah in order to explore the reason for the existence of *Natami* over decades in cities.

1.1 Research Question

Are the characters of the built environment and the prevailing city functions cause to the existence of *Natami* in Pettah?

1.2 Research Objectives

To identify the relationships among *Natami*, built environment and the city functions of Pettah.

2. Literature review

2.1 History of traditional loading and unloading workers

“Call for a sustainable transportation does not reveals the need of new technology for low carbon emission or massive new projects. Instead it is to promote existing traditional NMT.”

-World Bank (1999)-

According to Benjamin, “coolies” are the origin of traditional loading and unloading workers (Benjamin, 1980). These coolies were engaged in loading and unloading of goods and transporting passengers using carts and rickshaws. Although many of the motorized modes alter these practices, wholesale markets in countries such as Zegyo Market, Mandalay, Khari Baoli Street-Old Delhi and Sampheng Market-Thailand etc. follow this practice.

When it comes to the Sri Lankan context, Indian origin loading and unloading workers were in Pettah (“*Natami*”) since the 1950s. (Rathnaweera, 2014) From the British era Pettah began to expand as the main commerce and trade center. Due to the reluctance of natives to engage in loading and unloading in Pettah, Indian coolies were brought. Meanwhile, they were engaged in Rickshaw pulling too. In the colonial era, goods were carried by “*watt?*” or cart, catering to the transportation need of highly congested areas where access and free movement was not possible for motorized modes of transport. (Marga, 1978) But with the expansion of the trade and commerce activities “*watt?*” was replaced by hand pull carts. According to Rathnaweera, in the 1950s only one cart lender lived in Pettah and these carts were imported from abroad. This cart business was initiated by a merchant called P.S. and there were about 150 carts there. They were rented at Rs.1 per day. Even decades back, most of the transactions happened to be based on “trusting each other”. Risseuw (1988) also mentioned that virtually it is impossible to end this “trust-based loading and unloading network”. (RISSEEUW, 1988)



Figure 20- Traditional loading and unloading workers (*Natami*) in Pettah, Sri Lanka



Figure 21- *Natami* at Edinburgh Market-1976

Source: www.lankapura.com

2.2 *Natami* in the International standard classification of occupation (ISCO)

The International Labor Organization (ILO) represents the labor force in the entire world. The guidelines and goals introduced by the ILO are implemented by the Ministry of Labor of a particular country.

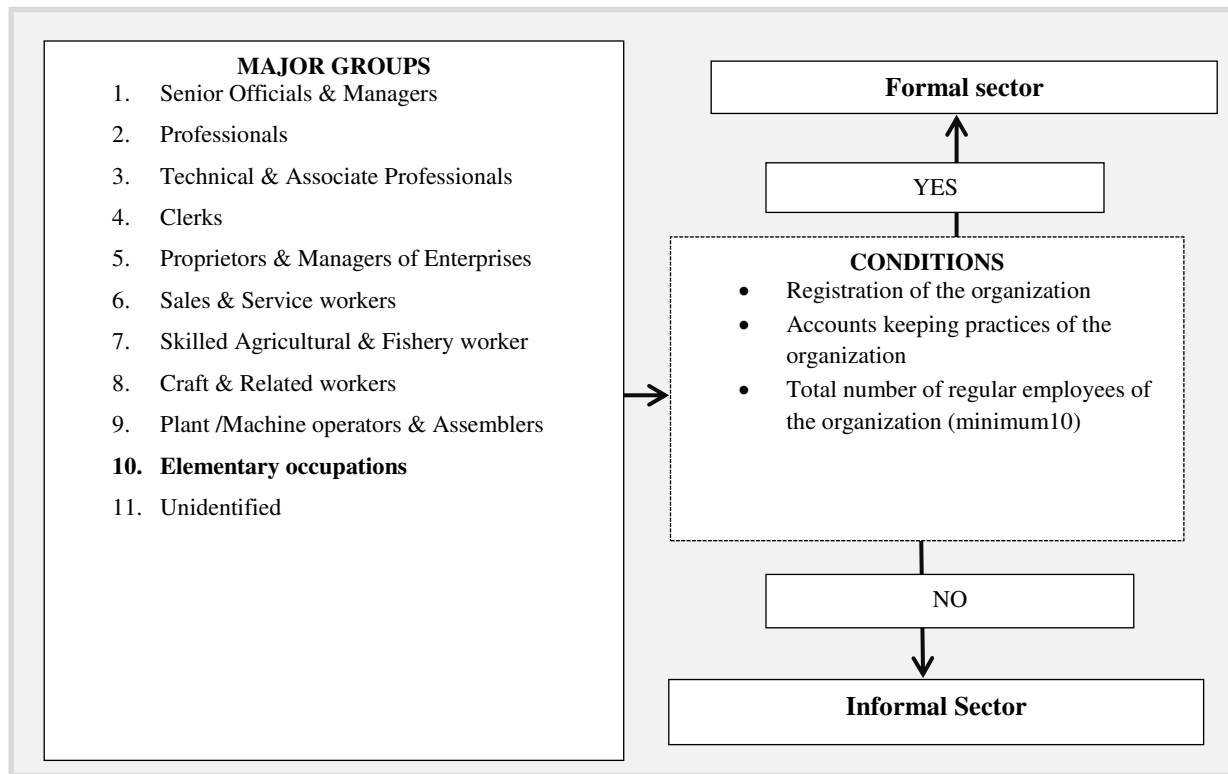


Figure 22- Procedure in identification of formal and informal sectors

Source: International standard Classification of Occupation (ISCO) prepared by ILO, Department of Census and Statistics (2012), *Sri Lanka Labour Force Survey, Annual Report 2012*

According to the above chart there are 11 major groups. Within that ‘Elementary **Occupation**’ is the 11th major group. According to the ILO under the 11th major group there is a sub-group called ‘Transport labors (933)’. But *Natami* do not satisfy any of the requirements that ILO considered to be a Formal sector labor. Therefore *Natami* as an occupation do not satisfy the above conditions. Thus, *Natami* are within the informal sector in the Sri Lankan labor force.

2.3 Informal Economy

According to an ILO study of the Urban Informal sector, Sethuraman defined the informal sector as follows;

‘Small-scale units engaged in the production and distribution of goods and services with the primary objective of generating employment and incomes to their participants notwithstanding the constraints on capital, both physical and human, and know how.’

According to the Census and Statistics department, the contribution from the informal sector to the Gross Domestic Product (GDP) is 62.7%. From that 50.9% is contributed from the non-agriculture sector. (Department of Census & Statistics, 2011) The statistics show that as well as the formal economy, informal economy too contributes to the functions of the city. Therefore, it is vital to examine the informal sector of the economy. Informal sector transportation is also a key component in the informal city economy.

According to Cervero(2000), informal transportation includes commercial transactions which distinguish them as transportation services from the provision of free lifts, whether by acquaintances or hand truck drivers all common forms of mobility in many poor, rural areas. (Cervero, 2000) According to the above definition, transportation modes such as pedicabs, cycle rickshaws, horse carts and hand pull carts, for hire-motorcycles, auto rickshaws, and truck passenger transport can be considered as informal transportation modes.

3. Selection of a case study

Pettah was selected as the case study to carry out the research as *Natami* is a frequent sight in Pettah comparative to the other places in Sri Lanka. Also, the history of Pettah is combined with the movements of *Natami*, as *Natami* is an occupation that originated with the Colombo Port.

The Pettah Grama Niladhari Division (GND) is predominantly a commercial area. According to the Census and Statistics Department, in 2012, Pettah provided accommodation only to 1749 people. But according to Pettah GND the commuter population of Pettah is 300,000. Hence, Pettah is the best case study to investigate the role of *Natami* wholesale and retail trading.

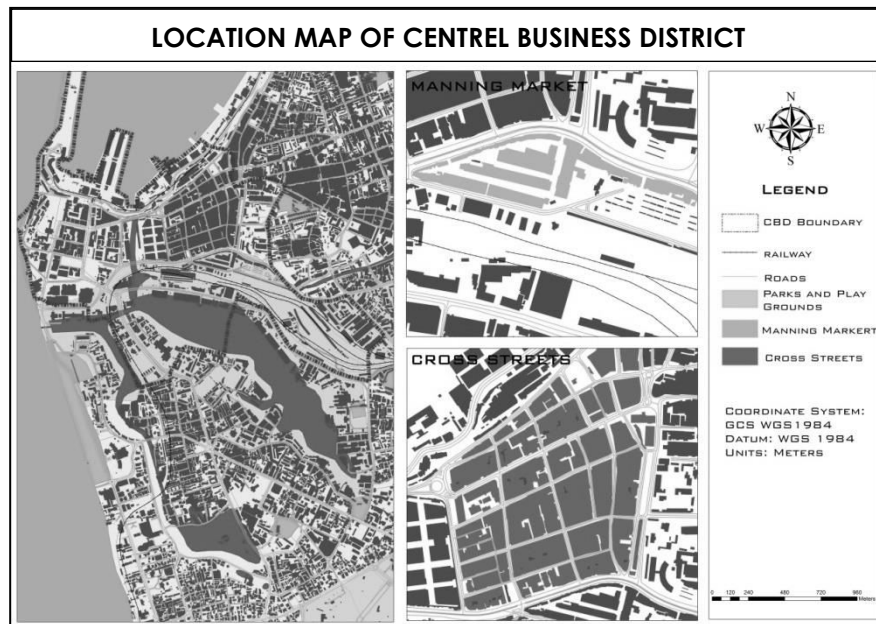


Figure 23- Location map of the case Study, Pettah, Colombo

In brief, Pettah can be introduced with the quotation of Indi Samarajiva,

‘People work hard in Pettah, selling, transporting, and dealing. As tourists we’re just passing through. Amidst the crowds, people drag hand carts full of onions, sprats, or like 20 televisions. It’s hot, it’s congested and I don’t know how they do it’
 (Source - Indi Samarajiva, *The Sunday leader*, Thursday, October 02, 2014)

It reveals how *Natami* make Pettah a dynamic place, where people remember Pettah by the movements and activities of *Natami*. Therefore, Pettah GND Division was selected as the case study.

4. Methodology

The methodology was followed by a series of techniques in order to capture more accurate data from the busy lives of *Natami*. Preliminary Observation/Eyeballing, Activity audit (On site Documentation), Semi-structured, In-depth Interviews, Photography survey/Time lap photographs, Behavior mapping- People centered mapping, Interviews carried out from different groups are the key methods followed. Through preliminary observations, the amount of *Natami* in the selected study area was counted as 4000. (This is an approximate value calculated by the author referring to the *Natami* registry of Association of Vegetables and Fruit Merchants Association (AVFMA)) and other sources)

4.1 Sampling method

Considering the population, the geographic area and the character of the case study, it is difficult to interview the entire population. Therefore, Stratified random sampling method was applied as it ensures greater accuracy. Although the population is large, by using the stratified random sampling method, the population can be reduced into similar strata.

4.1.1 Steps of identification of stratified random samples

Identification of homogeneous Strata

Within Pettah, cross streets and the Manning market are the main wholesale and retail trade magnets. Therefore, the study area was classified into similar strata in terms of dominant trade type.

Table 1- Identification of homogeneous strata in terms of dominant trade type

	Street name	Activity	Dominant Trade type
1	Front Street	Shoes, Bags, Suitcases	Retail
2	First Cross Street	Electrical goods	Wholesale
3	Second Cross Street	Cosmetics and Tailoring (Cloths, shoes, bags)	Retail
4	Third Cross Street	Fabrics,Cloths	Wholesale,
5	Fourth Cross Street	Ayurvedic medicines,Onions	Wholesale
6	Maliban Street	Wedding Items, Stationary	Wholesale
7	Keyzer Street	Bags, Fancy items	Wholesale
8	Prince Street	Hardware, Bags, Leather, Fancy items, Toys	Wholesale
9	Sea Street	Jewellery, Gold and gems	Retail
10	Manning Market	Wholesale and Retail trade	Wholesale
11	Fifth Cross Street	Vegetables, Fruits	Wholesale
12	BodhirajaMawatha	Vegetables, fruit	Retail
13	Bankshell Street	Plastic, Chemicals	Wholesale
14	Mayuri Lane	Old leather, cloths	Wholesale
15	2 nd Rohini Lane	Old shoes,Cloths	Retail
16	1 st Rohini Lane	Old Shoes , Cloths	Retail,
17	Main Street	Cloths, Leather items,Bags	Wholesale, Retail
18	OlcotteMawatha	Bags, Phones, cloths (many uses)	Retail
19	China Street	Party Intems,glass wear, ceramic,Kitchen utensils	Wholesale
20	St. John road	Cardboard, Sponch	Wholesale

Source: Compiled by the author through the semi structured interviews and target group discussions

Sample selection

According to the above table, there are two homogeneous strata based on the trade type. ‘Wholesale trade dominant streets’ and ‘retail trade dominant streets’ are the main identified city functions as the research questions about the city function. Therefore, 80 *Natami* were selected as the sample from the total population. (2% of the population)

According to the above table, the ratio between wholesale dominant streets and retail dominant streets is 12:8. Therefore 48 *Natami* were interviewed from the wholesale dominating streets and 32 *Natami* were interviewed from the retail dominating streets. In order to identify the relationship between *Natami* and the built environment Keyzer Street (representing cross streets) and Manning Market (as it is the dominant vegetable wholesale market in the country) were selected randomly.

5. Analysis

Analysis section contains two main analysis. The first part of the analysis attempts to identify the relationship between *Natami* and the city functions and the second part of the analysis is focused on the relationship between *Natami* and the built environment.

5.1 Identification of the relationship between Natami and the city functions of Pettah

Through data collection 13 nodes were identified within the functioning network of Pettah. They are Wholesale good importers and exporters, *Natami* cart lenders, Wholesale merchants, cart repairers, Security Service Providers, Route Owners, Farmers, Transporters (Lorry Services), Accommodation providers, Street tea shops, Port and consumers. Among them, some are attached to Cross streets and some to the Manning Market. There are some nodes that are common to both cross streets and the Manning Market such as *Natami*, wholesale merchants, Street tea shops and consumers. In Jane Jacob’s *Death and Life of Great American Cities*, she mentions that ‘An interviewing but different set of relationships must grow up; but these are working relationships among people.’ This character can be seen in Pettah apparently.

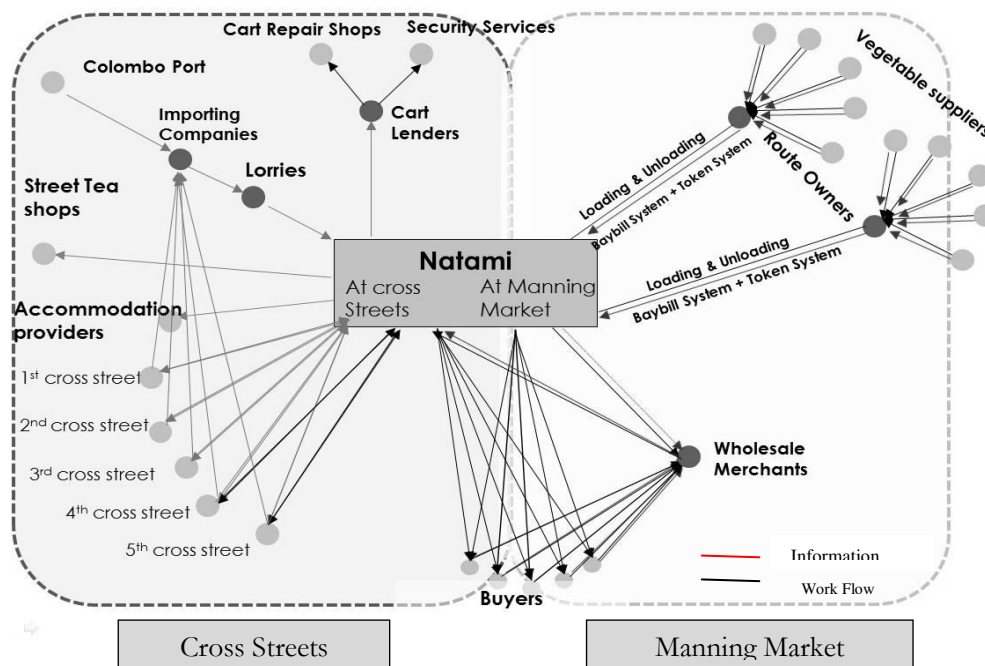


Figure 25- Functioning Network of Pettah

Source: Compiled by the author through the semi structured interviews and target group discussions

In the above diagram, simultaneous to the work flow, information is also flowing. The farmers who are in rural areas sell their vegetables and other goods to the vegetable suppliers. Then, the vegetable suppliers carry the goods via a lorry to Pettah. At the Pettah Manning Market, vegetable suppliers have to meet the relevant route owners¹. The vegetable suppliers bring an information bill called ‘Waybill’.



Figure 26- Waybill

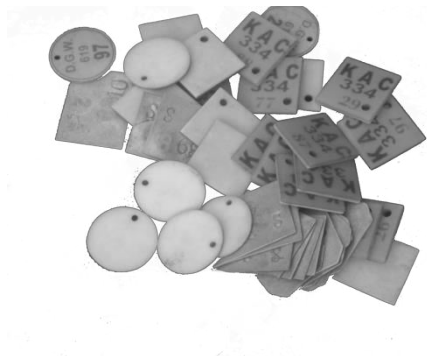


Figure 27 - Tokens

Source: Photographed by the author

These waybills include how many pieces², to whom³ and from whom. All the waybills are collected by the route owners and they immediately pass them to *Natami*. Accordingly, *Natami* read these waybills and engage in unloading. This is the same process that happens in many of the leading courier service providing companies. The only difference is *Natami* does it manually, while many of the courier services do it using barcodes and other computerized systems. Meanwhile, the wholesale merchants get orders from the consumers. Following the same method mentioned above, *Natami* engage in loading activities too. Although Olcotte Mawatha separates the connection between Pettah and the Manning Market physically, *Natami* recreate the interaction between Manning Market and the 4th, 5th cross streets of Pettah. Therefore, in

¹ There is an intermediate that represent every part of Sri Lanka. Ex: There is a route owner who represents the southern part of Sri Lanka. So the vegetable suppliers from the southern part have to contact their relevant route owner even to park their lorry within the Manning Market premises.

² Manning Market transacts on piece rate. 10kg gunny bag is considered as a piece.

³ Each wholesale merchants shop has a number. The waybill includes this number.

terms of functions, Manning Market and 4th, 5th cross streets follow the same functions. Even *Natami* in these areas do not prefer to engage in loading and unloading activities in other cross streets. For each completed waybill the relevant wholesale merchant offers the *Natami* with a Token. At the end of the day, *Natami* count them and get the money according to the Tokens collected.

Wholesale merchants in the cross streets keep orders to the international importing agencies about the goods they want to import from the port and send the lorries what are available to carry the goods to Pettah when the ordered goods arrive to the port. Then, *Natami* engage in unloading activities according to the instructions of the wholesale merchant in Pettah. Meanwhile, the merchants receive orders from consumers. Accordingly, the merchants collect all the orders and transfer them to *Natami*.

In order to find out the most influential person in the above network, 'Centrality' was calculated. According to Newman (2010), in network analysis, 'centrality' is considered an indicator which identifies the most important pinnacle within a graph. Initially four types of centrality measures were calculated using the software –'SocNet V-1.5'.

Information Centrality (IC)

Information centrality is to investigate 'How much 'X' person removal affect network information efficiency of the network'.

$$IC(i) = \left[\frac{1}{n} \sum_j \frac{1}{L_{ij}} \right]^{-1}$$

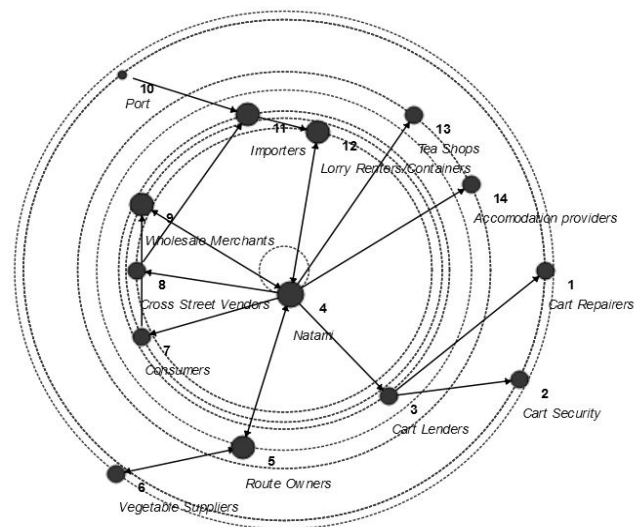
The information measure L_{ij} between two nodes is defined as the reciprocal of the topological distance d_{ij} between the corresponding nodes
 N = all nodes in the network

The table below shows the quantitative values of how much each node is central in the above network in terms of information flow.

Table 13- Information Centrality Values of the nodes

Node	IC' value	%IC
1-Cart Repairers	0.0513	5.13
2- Cart Security Providers	0.0513	5.13
3-Cart Lenders	0.0772	7.72
4- <i>Natami</i>	0.166	11.6
5-Route Owners	0.0712	7.12
6-Vegetable Suppliers	0.0486	4.86
7-Consumers	0.0794	7.94
8-Cross Street Vendors	0.0824	5.13
9-Wholesale Merchants	0.0794	7.72
10-Port	0.0513	5.13
11-Importers and Exporters	0.0772	7.72
12-Lorry Renters	0.0824	8.24
13- Tea Shops	0.0661	6.61
14-Accommodation Providers	0.0661	6.61

Figure 28- Graphical interpretation of the Information centrality values of the nodes



It reveals that *Natami* are much more centralized compared to the other nodes in the network diagram. Therefore the removal of *Natami* from this functioning Network of Pettah will highly influence on the network efficiency.

Closeness Centrality(CC)

Closeness Centrality concentrates investigates how close a node is to all other vertices in the network.

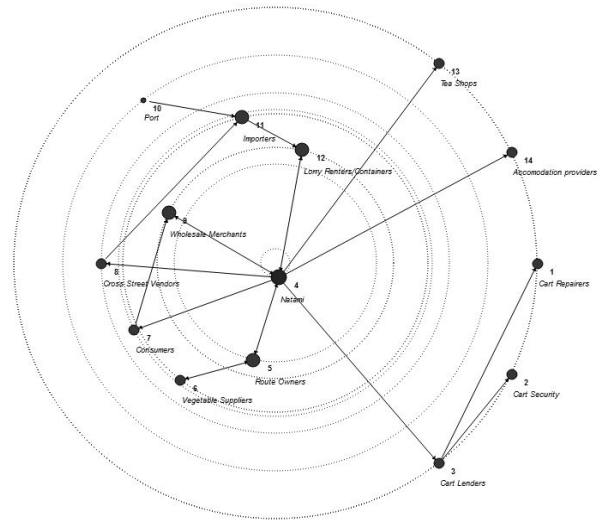
$$CC_i = (N - 1) / \sum_{j=1}^k L_{ij}$$

Where: CC_i = Closeness centrality of node i
 L_{ij} = Cumulative impediment between nodes i and j, with j ∈ N and i ≠ j
 N = all nodes in the network

Table 14 – Closeness Centrality Values of the nodes

Node	CC' value	%CC
1-Cart Repairers	0	0
2- Cart Security Providers	0	0
3-Cart Lenders	0	0
4- <i>Natami</i>	0.566	56.6
5-Route Owners	0.367	36.7
6-Vegetable Suppliers	0.249	24.9
7-Consumers	0.24	24
8-Cross Street Vendors	0.201	20.1
9-Wholesale Merchants	0.328	32.8
10-Port	0.112	11.2
11-Importers and Exporters	0.249	24.9
12-Lorry Renters	0.328	32.8
13- Tea Shops	0	0
14-Accomodation Providers	0	0

Figure 29-Graphical interpretation of the closeness Centrality values



The above table reveals that *Natami* have the highest closeness centrality throughout the network. If Freeman’s (1979), definition for Closeness Centrality related to this context (CC measures ‘To what extent a node is close to all the other nodes along the shortest paths of the network?’) the answer to that question is ‘*Natami* are 56.6% close to all the other nodes along the shortest paths of the network’. In terms of Closeness centrality *Natami* are a critical node that contributes to the network efficiency of Pettah.

Degree Centrality (DC)

Degree Centrality provides the answer to the question of ‘How many people interact with a node in the network?’

$$CD_i = \frac{\sum A_{ij}}{(N - 1)}$$

CDi = Degree centrality of node i

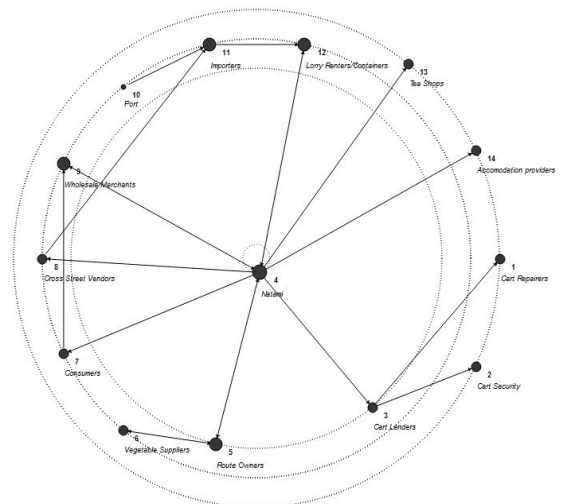
Aij = Direct (transfer-free) link between nodes i and j, with j ∈ N and i ≠ j

N = all nodes in the network

Table 15 – Degree Centrality Values of the nodes

Node	CCvalue	%CC
1-Cart Repairers	0	0
2- Cart Security Providers	0	0
3-Cart Lenders	0	0
4- <i>Natami</i>	0.566	56.6
5-Route Owners	0.367	36.7
6-Vegetable Suppliers	0.249	24.9
7-Consumers	0.24	24
8-Cross Street Vendors	0.201	20.1
9-Wholesale Merchants	0.328	32.8
10-Port	0.112	11.2
11-Importers and Exporters	0.249	24.9
12-Lorry Renters	0.328	32.8
13- Tea Shops	0	0
14-Accomodation Providers	0	0

Figure 30- Graphical interpretation of the Degree Centrality values of the nodes



This reveals that *Natami* have the highest degree centrality while route owners own the second. The above analysis shows that ***Natami* have the highest amount of nodes directly connected, proportionate to the other nodes in the network.**

Betweenness Centrality (BC)

Betweenness Centrality addresses the question of ‘To how many people a node act as a BRIDGE’ in a network. The diagrams below and results provide the answer in the case of functioning network of Pettah.

$$CB_k = \sum P_{ij}(k) / (N-1)(N-2)$$

CB_k = Betweenness centrality for route segment k

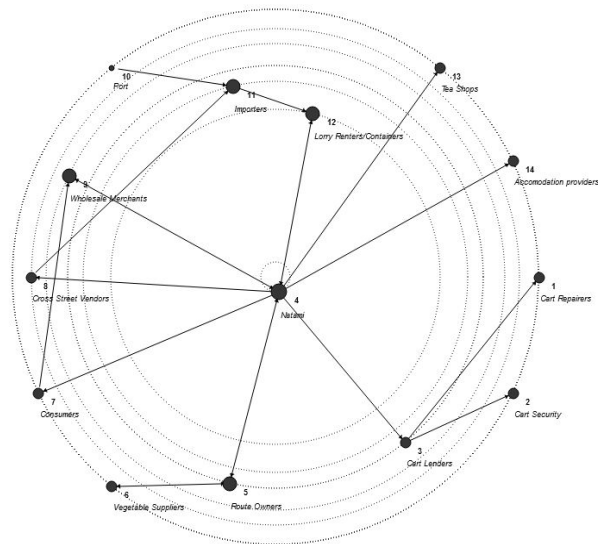
$P_{ij}(k)$ = paths between nodes i and j that pass through segment k, for all $i, j \in N$ and $i \neq j$

N = all nodes in the network

Table 16 Betweenness Centrality Values of the nodes

Node	BC value	%BC
1-Cart Repairers	0	0
2- Cart Security Providers	0	0
3-Cart Lenders	0.115	11.5
4- <i>Natami</i>	0.519	51.9
5-Route Owners	0.115	11.5
6-Vegetable Suppliers	0	0
7-Consumers	0	0
8-Cross Street Vendors	0.0385	3.85
9-Wholesale Merchants	0.0705	7.05
10-Port	0	0
11-Importers and Exporters	0.147	14.7
12-Lorry Renters	0.205	20.5
13- Tea Shops	0	0
14-Accomodation Providers	0	0

Figure 31- Graphical interpretation of the Betweenness Centrality values of the nodes



According to the above outputs *Natami* act as a bridge to the other nodes in 51.9% in the network. It is the highest node which has the highest BC.

According to the above centrality calculations of the functioning network of Pettah, it is revealed that *Natami* are the most influential people within the functioning network of Pettah.

Activity mapping

Although the above analysis reveals that *Natami* are a significant character of the functioning network of Pettah, the research paper also attempts to examine how *Natami* organize their space at different time periods of the day; considering the two cases of Keyzer Street and the Manning Market.

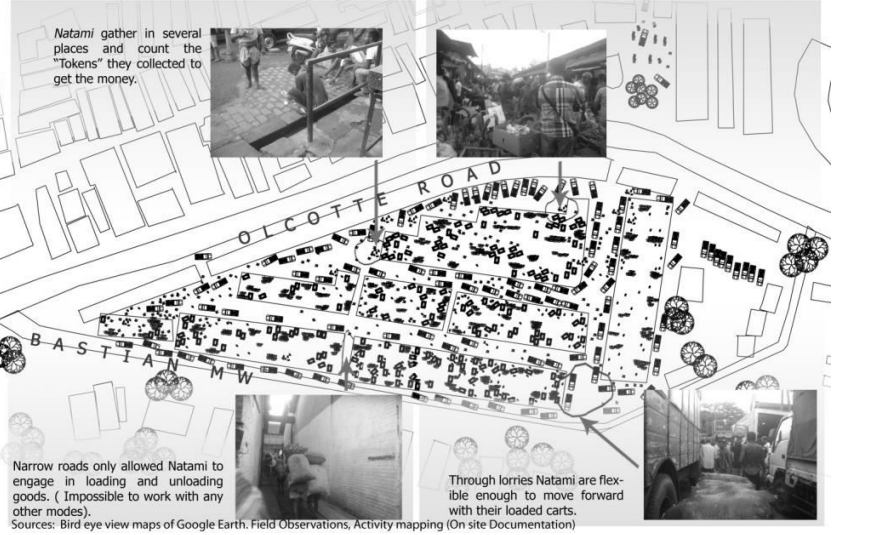
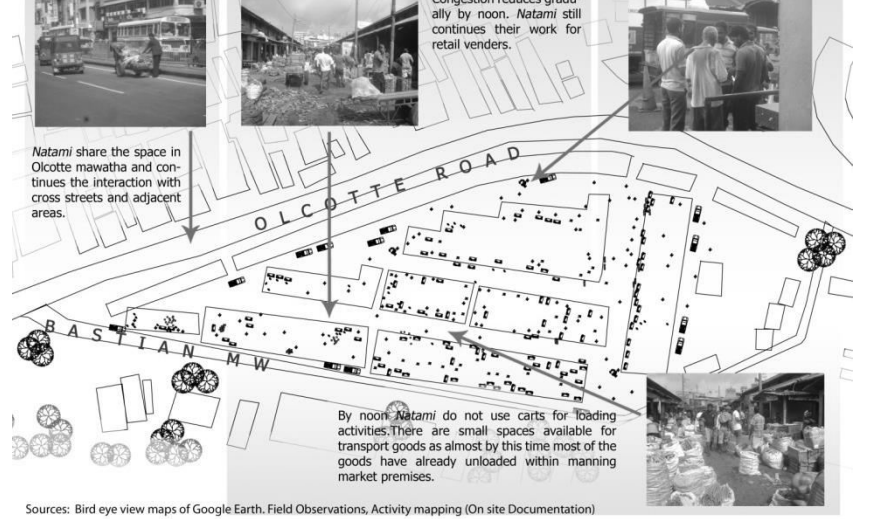
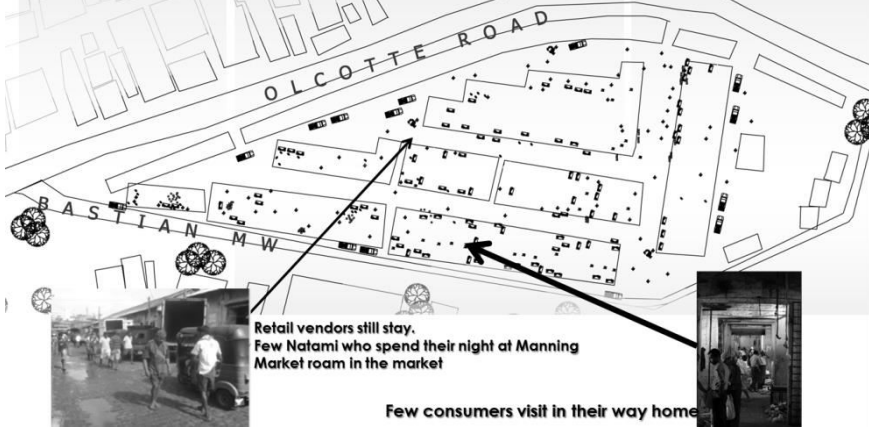
Table 6- Activity Mapping-Keyzer Street

Time Duration	Activity Mapping- Keyzer Street
6.30 a.m to 8.30 a.m	<p>Street tea shop is the first place that get active in the street with their constant Natami consumers.</p> <p>Only Natami can transport goods to the shops where only accessible through narrow pathways.</p> <p>Through lorries Natami move easily to their destinations even through a narrow space.</p> <p>In the morning only movements can observe. But around 7.00 a.m the road reduces its congestion.</p> <p>Sources: Bird eye view maps of Google Earth, Field Observations, On site Documentation</p>
11.30 a.m to 1.30 p.m	<p>"Natami" They chat, interact and relax in Pettah. They have become a part of Pettah.</p> <p>There are flock of carts parked on the street demarcating the parking area.</p> <p>They customize the space. Natami are attached to Pettah. They have become a part of Pettah.</p> <p>"Natami" are the key consumers of the tea shops.</p> <p>Mobile tea shops and tea shops on the street are full of Natami.</p> <p>"Eyes on the streets" adding defense to the street at noon.</p> <p>Sources: Bird eye view maps of Google Earth, Field Observations, Activity mapping (On site Documentation)</p>
4.30 p.m to 6.30 p.m	<p>ACTIVITY MAPPING - 4.30 P.M - 6.30 P.M KEYZER STREET, PETTAH</p> <p>From morning to evening this tea shop generates continuous income. Natami used to stop the cart and have-a-tea from this place.</p> <p>Among threewheelers, on street loading and unloading, passengers, lorries, Natami share the space and move quickly and easily.</p> <p>Evening Pettah is busy with more vehicles, consumers and heavy load of Natami driven carts.</p> <p>"Eyes on the streets" In evening also can observe some gathering pockets.</p>

The above activity maps were drawn through the observations derived from field observations and activity mappings carried out in the morning, noon and evening. They interpret different perspectives of the relationship of Natami and the city functions. Desmond Morris, in his book 'Human Zoo', interprets cities as 'city is not a concrete jungle. But it is a human zoo'. This definition is reflected in Pettah. Pettah does not sleep even at night. Narrow streets do not give a sense of security to the people who travel. Therefore, at night, Pettah seems to be a concrete jungle. They are the people who wake Pettah and they turned the concrete jungle into a human zoo. From 4.30 am to 6.00 am there are only loaded carts moving fastly. They do not have time to stay. They drag their carts rapidly. But the opening and closing times of

the tea shops and mobile tea shops (kinetic commercial spaces) harmonize with the working hours of *Natami*. According to Jacobs(1961), *fluidity of opportunities is an asset, not a detriment for encouraging city – neighborhood stability*. Therefore *Natami* are identified as an opportunity generating magnet in Pettah.

Table 7-Activity Mapping-Manning Market

Time Duration	Activity Mapping- Manning Market
6.30 a.m-8.30 a.m	 <p><i>Natami</i> gather in several places and count the "tokens" they collected to get the money.</p> <p>Narrow roads only allowed <i>Natami</i> to engage in loading and unloading goods. (Impossible to work with any other modes).</p> <p>Through lorries <i>Natami</i> are flexible enough to move forward with their loaded carts.</p> <p>Sources: Bird eye view maps of Google Earth, Field Observations, Activity mapping (On site Documentation)</p>
11.30 a.m – 1.30 p.m	 <p><i>Natami</i> share the space in Olcotte mawatha and continues the interaction with cross streets and adjacent areas.</p> <p>Congestion reduces gradually by noon. <i>Natami</i> still continues their work for retail vendors.</p> <p>By noon <i>Natami</i> do not use carts for loading activities. There are small spaces available for transport goods as almost by this time most of the goods have already unloaded within manning market premises.</p> <p>Sources: Bird eye view maps of Google Earth, Field Observations, Activity mapping (On site Documentation)</p>
4.30 a.m – 6.30 p.m	 <p>Retail vendors still stay. Few <i>Natami</i> who spend their night at Manning Market room in the market</p> <p>Few consumers visit in their way home</p>

Most of the food stands open from the morning (around 5.00 a.m to 5.30 a.m) and only the movements can be observed of *Natami*. Their rush and speed give energy to the entire environs. There are two reasons for their continuous speedy movement in the morning. They transport goods in wholesale. Their slightest delay may cause a massive impact on the price determination of the goods. The goods in their carts are to be delivered to different areas of the country. They know their responsibility although many of the policy makers forget their contribution.

By noon, they are relaxed. They sleep, they chat or they gather at certain points to gossip. Their eyes are always on the street. Those streets are their homes. They are the people whodemarcate the parking area of the street for that day. They defend the street. Jacobs too emphasized that each additional pair of eyes, and every increase in their range, is good for dull grey areas.

By evening, the situation changes. *Natami* become busier again, as in the morning. But the streets get a face of chaos as there are many customers unlike in the morning. Among vehicles and people, *Natami* do not feel difficult to find their way to carry the heavy loads. Then, the rapid movements decline gradually over time.

Within one day, Pettah streets get different characters with the activities of *Natami*. *Natami* are the key role players of Pettah. Therefore, activity mapping and field observations illustrate that *Natami* is a key character who makes activities happen in Pettah.

Around 5.30 a.m all the lorries park within or adjacent to the Manning market. In cross streets, *Natami* are more or less independent. They are individually responsible for the work they do. In the Manning Market, there are certain organizations that exercise influence on *Natami*. So, they are told to unload all the goods by 6.30 am. Morning is the climax of the day as most of the activities start and finish in the morning. *Natami* have to cross Olcotte Mawatha with their carts or heavy load on their bare backs to distribute in 4th and 5th cross streets. Although *Natami* carry heavy bags they halt near the traffic lights until the green light appears. They share the space smoothly with other modes. In the morning, Pettah is full of movements. *Natami* bring goods such as onions and other from cross streets to the Manning Market and they also carry vegetables and other goods from the Manning Market to cross streets

These activities only take place in the morning. By around 9.00 am, all the large scale transactions are completed. All the vegetables and other food types are almost unloaded by this time and there are few spaces available for more. With these spaces *Natami* find easy ways to transport the goods. Around 11.00 a.m to 12.00 noon all the transactions are finished. According to Hector Kobbekaduwa Agrarian Research and Training Institute, there are about 150 tons of vegetables transacted in the Manning Market. *Natami* are the group of people that move these vegetables. Within a short time period, Manning Market goes through different stages of activity. In such circumstances, the absence of *Natami* will stop each and every activity of the Manning Market as they are the activity generators of the Manning Market.

In the evening, the Manning Market does not have many functions and the Colombo Municipal Council (CMC) officially closes the Manning Market. But still, there are some *Natami* roaming in the area and they stay their night in Manning market.

5.2 Identification the relationship between *Natami* and the Built environment

Literature review reveals that *Natami* were in Pettah over decades. Although many of the NMT modes have been replaced by Motorized modes within the last few decades, *Natami* still exist in Pettah. In order to identify whether there is a relationship between *Natami* and the built environment, the analysis below was followed. In order to identify the relationship between *Natami* and the built environment, a streetscape study was done in Keyzer Street.



Figure 32- Streetscape Study of Keyzer Street

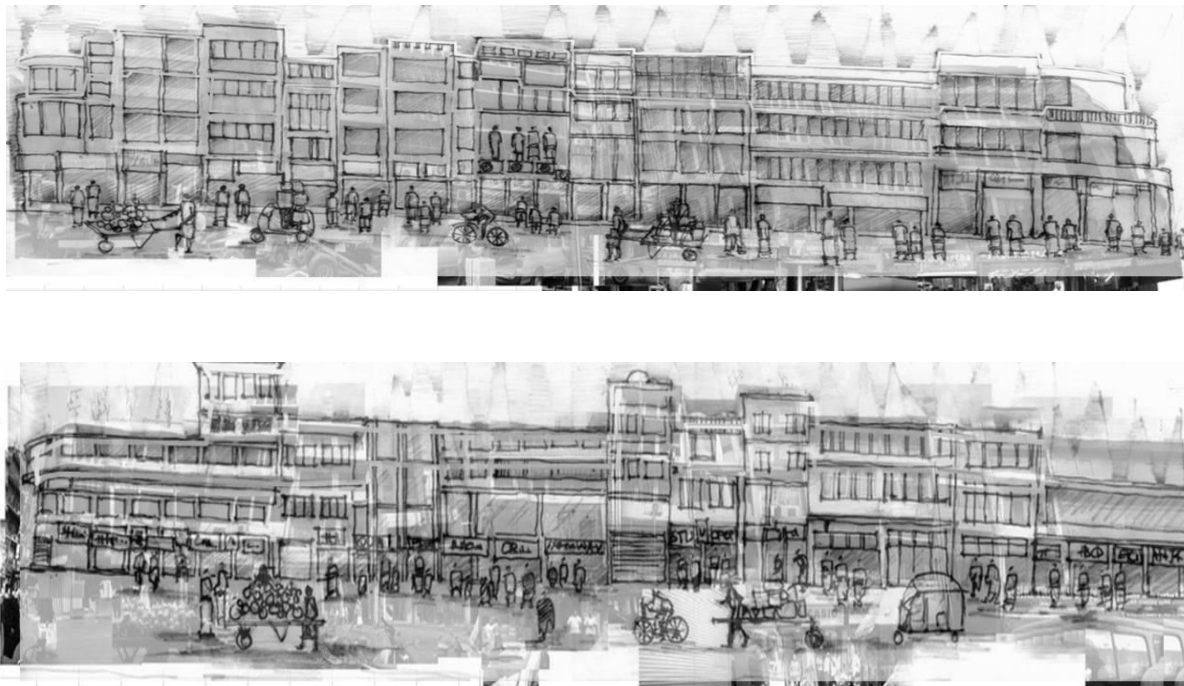


Figure 33-Cross Section-Keyzer Street

The maps above show that the store rooms of the shops in Keyzer Street are mostly on the upper floors of the building. Although the shop owners hire other modes such as three wheels to transport the goods, they have to hire a *Natami* to carry the goods to the upper floors. Accordingly, *Natami* is an occupation that emerges from this built environment. This built environment facilitates the existence of *Natami* in this environment.

Figure 34- Cross Section-Manning Market

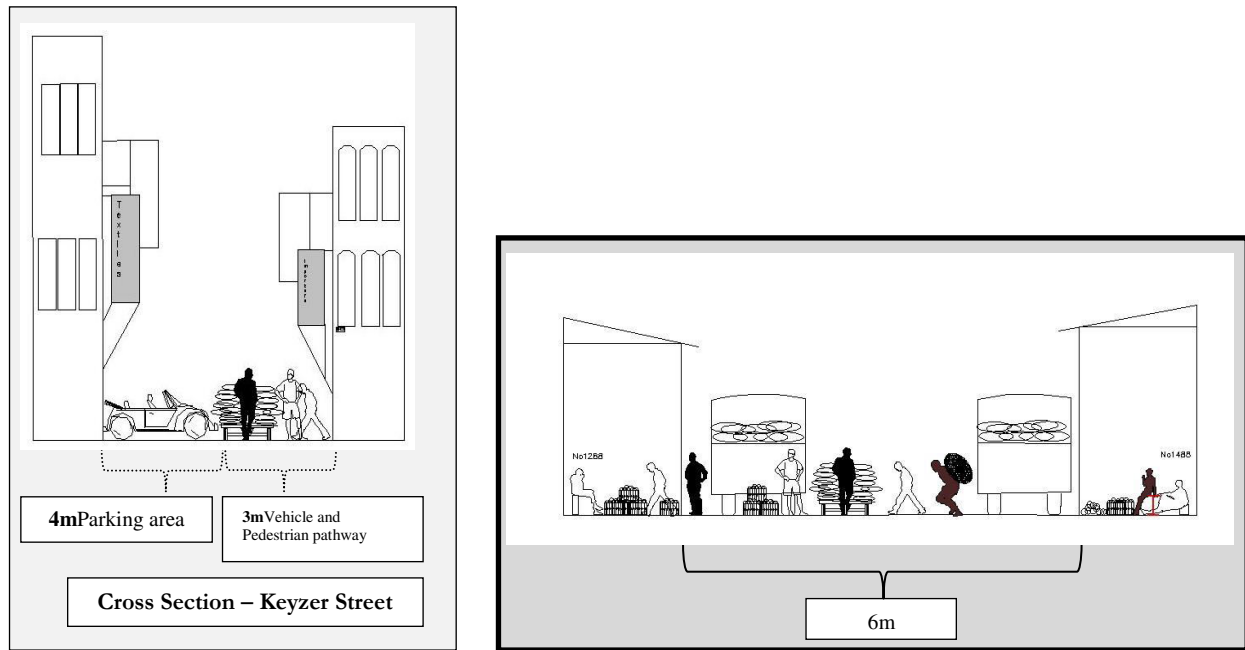


Figure 35- Narrow Streets and spaces in Manning Market



The above cross-section reveals that this built environment supports the existence of *Natami*. Thus, the survival of *Natami* is combined with this built environment.

According to the above details and cross-sections, it reveals that, within this context, it is impossible to use another mode of transportation to engage in loading and unloading activities. Accordingly, in Manning Market also can find a relationship between *Natami* and the built environment just as Keyzer Street. Therefore, it is possible to conclude that the existing built environment prevents any other loading and unloading mode entering the Manning Market while *Natami* play a vital role in contributing to the efficiency of the prevailing networks.

As well as the relationship between *Natami* and the city functions, there is a positive relationship between *Natami* and the built environment too. The above analysis reveals that the existence of *Natami* depends upon the prevailing built environment. If these narrow streets widen there is a possibility to experience a modal shift from *Natami* to motorized modes. At present, Bodhiraja Mawatha and 5th cross streets are experiencing the arrival of motorized modes. When consider the other streets, although they hire a three-wheeler they have to hire a *Natami* to transport the load to the upper floors, where their wholesale stocks are stored. Therefore, this built environment only facilitates *Natami* who were in Pettah for decades.

When consider the above facts and figures *Natami* play a vital role in making the city networks/functions efficient and dynamic. Therefore *Natami*, the built environment and the city functions are three knots in one rope.

5. Conclusion

When considering the analysis, it reveals that *Natami* are highly attached to the functioning network and the built environment of Pettah. The built environment of Pettah reveals the existence of *Natami*. In Pettah, throughout the busy streets, they create livable places where they stop, talk and share their tea. They are within the interwoven network of Pettah. The analysis reveals that *Natami* is the focal point of this network where most of the ties intersect. Their carts create safe environment for elders, children, and the handicapped. *Natami* engage in on-street loading and unloading, but their work does not disturb the pedestrians who use it. *Natami* share the road with them mutually.

The built environment of Pettah, with its narrow streets and vertical rhythmic buildings, encourage the existence of *Natami*. At the same time, *Natami* contribute to the functioning wholesale and retail networks of the city to support the smooth flow of the city functions of Pettah. Therefore, it is an interdependent flow where the built environment encourages the existence of *Natami* and *Natami* contribute to the functions of Pettah. Ultimately, Pettah attracts many people while creating diverse surroundings that many scholars such as Gordon Cullen, Christopher Alexander, Jane Jacobs, Donald Appleyard (Humanistic approaches to Urban Design) have emphasized.

The network analysis reveals that the network to which *Natami* are attached to, is very complex and interwoven. This is the reason behind the efficiency of Pettah. According to Jacobs (1961) 'superficial architectural variety may look like diversity, but only a genuine content of economic and social diversity resulting in people with different schedules which it gives meaning to the place'. Therefore, it is true enough that Pettah has a superficial architecture but the economic and social diversity enforced by the centrality of *Natami* only enhance the efficiency of Pettah. Therefore, the above analysis identifies *Natami* as a part of Pettah.

Hence, the research study reveals that there is a positive relationship between *Natami* and the built environment, where the built environment supports the existence of *Natami* and *Natami* contribute to the city functions of Pettah. If one node of this cycle were disturbed or damaged, the entire system will be disturbed or will collapse. Thus, in the future, when making decisions related to Pettah, it is a crucial consideration to align the decisions with these relationships as they are not visible at once. If not, the entire system will collapse.

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Factors of the Built Environment that Affects the Walkability in a Sri Lankan Urban Neighborhood

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Abstract

The quality of the neighboring environment plays a major role in encouraging people to walk when attending to their daily needs. Although many previous studies identified a relationship between different factors of the built environment and the level of walkability, this interdependence is poorly understood in urban planning in Sri Lanka. This Study analyses the relevance of thirty factors of the built environment, identified by previous studies as affecting the walkability, to Sri Lankan urban context, using thirty five residents within a selected neighborhood in the town of Panadura. The identified factors were examined within a 100m radius of each participant's residence through a questionnaire survey and field observations. Chi-squared analysis and bivariate correlation analysis were carried out to identify the most decisive factors for walkability. The results show that block length, the number of street lights, vehicle ownership, having relatives in the neighborhood and unpleasant land uses are the most significant factors.

Keywords: walkability, factors of built environment, neighborhood

1.0 Introduction

Numerous studies have observed that residents of higher-density, mixed-use neighborhoods tend to walk more and drive less than do the inhabitants of lower-density, suburban areas (Cervero and Duncan, 2003, Crane and Crepeau, 1998, Frank et al., 2007). Pedestrianization has become an integral part of any sustainable, modern urban design, where pollution-free, convenient, safe, and comfortable pedestrian facilities are ensured. The influence of attributes of the built environment on habitual behavior patterns such as walking are not yet well understood by behavioral scientists (Sallis and Owen, 1999), but community design disciplines (particularly transportation and urban planning research) have identified some strong patterns of association (Frank et al., 2003). Some studies have reported the associations between perceived environmental variables and walking (Owen et al., 2004; Frank and Pivo, 1995). There are only a limited number of studies that have investigated the relationship between factors of the built environment and walkability in Sri Lankan urban setting. This paper further discusses the definitions and concepts of walkability, the built environment and the neighborhood. Further, it examines in detail the factors of the built environment that affect the level of walkability. In this case study of Panadura urban area, Chi-squared and bivariate correlation analysis were used to identify the most significant out of 30 factors which have been forwarded in literature as influential for walkability .

2.0 Literature review

2.1 Concepts of Walkability, the Built Environment and the Neighborhood

'Walkability' is becoming a buzzword in planning today, as new ideas of urbanism are spreading throughout the profession. Many individuals define walkability using different terms (e.g., proximity, accessibility, and suitability). Walkability is a measure of how friendly an area is to walking. It takes into account the quality of pedestrian facilities, roadway conditions, land use patterns, community support, security and comfort for walking (Ariffinand Zahari, 2013). Walkability is the measure of the overall walking and living conditions in an area and is defined as the extent to which

the built environment is friendly to the presence of people walking, living, shopping, visiting, enjoying, or spending time in an area (Abley, 2005). The built environment refers to the physical form of communities (Brownson et al., 2009), which has been operationalized in six dimensions: residential density, street connectivity, accessibility to services and destinations, walking and cycling. Leslie, (2005) defines a neighborhood as a physical environment in which all basic community facilities such as a school, playground and local shops are provided within a walking distance; an environment in which a community may have an easy walk to a shopping center where they may get the daily household goods, and employed people may find convenient transportation to and from work. Foesyth et al. (2007) show that neighborhoods can create and use a network of interactions and this connection help improve their quality of life as well as help get information, ideas, influences and resources. Accordingly, the built environment of a neighborhood plays a major role in enhancing the walkability by creating networks among the physical setting of communities.

2.2 Factors of the built environment that affect the walkability in Urban Neighborhoods

Researchers in planning and transportation have identified that diversity of land uses, access to facilities and street connectivity are the key aspects contributive to walkability in urban neighborhoods (Frank and Pivo, 1994, Cervero and Kockelman, 1997, Krizek et al. 2012). Similarly, the proximity of destinations, good weather conditions, safety and well-designed pedestrian facilities can significantly contribute to better perception of the walking environment (Ariffin and Zahari, 2013). Frank and Pivo, (1995) argue that population density and, to a lesser extent, pedestrian infrastructure, can affect the rate of walking. As Leslie (2005) mentions more varied and interesting built environment leads neighborhoods conducive to walking. Park and Schofer (2006) show that grid networks, sidewalks, setbacks and parking play a role in creating a pedestrian-friendly area. Further, they also show that large setbacks increase the effort required to reach buildings from the street; small building setbacks make commercial establishments and residences easily accessible to pedestrians. Nankervis, (1999) shows that out of the variables of weather, the average temperature and total precipitation impact walking. According to the study done by Campos et al. (2003), street lighting, the width of walk ways, the gradient of walk ways, weather conditions, proximity to main transport facilities and signage show a higher degree of importance in encouraging people to walk. At the same time, safety is also a point of concern for pedestrians’ walkability. Individuals who live in areas that are more walkable and have lower crime rates tended to walk more (Doyle et al., 2007). Further, Schofer (2006) also illustrates that pedestrian activity is associated with the level of personal safety within a neighborhood. Table 1 summarizes thirty factors of the built environment that affect the walkability in urban neighborhood as identified through the reference to literature in this study.

Table 17: Factors of Built Environment that affect Walkability in an Urban Neighborhood

Factor	Measures	Recent Literature
1. Land use variation	Entropy calculation	Ewing & Cervero, (2010), Forsyth et al, (2007), Cervero & Kockelman, (1997), Handy (2002), Sallis et al. (2005)
2. Accessibility / Connectivity		
• Distance to destinations	Time spent for walking from home to bus stop	Krizek et al (2010), Litman,(2010), Cervero&Kockelman, (1997), Saelens et al,(2003) Frank et al.,(2007), Frank et al.,(2004), Sallis et al., (2005)
• Street connectivity	Number of intersections within buffer	
• Block length	Block length of particular buffer	
• Street pattern	Grid = 1 Not grid = 0	
3. Facilities in walking ways		
• Presence of sidewalks	Available = 1 Not available =0	Frank &Pivo, (1994), Schlossberg et al.,(2007), Ariffin&Zahari, (2013), Senevirathna&Morrall, (2013)
• Sidewalk width	More than 3 feet =1 Less than 3 feet=0	
• Side walk paving treatment	Concrete Block Paving =3 Bricks Paving = 2 Asphalt Paving =1 Unpaved= 0	
• Disability infrastructure	Available=1	

	Not available=0	
• Walking trails	Available = 1 Not available = 0	
• Street furniture	Available = 1 Not available = 0	
• Traffic calming features	Number of traffic calming signals within the block	
• Cleanliness	Clean = 1 Not clean = 0	
4. Aesthetic		
• Attractive architectural design	Available = 1 Not available = 0	Humpel et al.,(2002), Owen et al.,(2004), Booth et al., (2000), Ball et al, (2001)
• Presence of street trees	Number of street trees within buffer	
• Recreation	Number of places to exercise	
5. Safety		
• Undesirable land uses & activities	Available =1 Not available = 0	Berrigan, (2002), Ariffin&Zahari,(2013), Southworth,(2005), Foster & Giles, (2008), Leslie et al.,(2005), Troy & Grove, (2008), Sapawi& Said,(2012)
• Vacant & abandoned buildings	Available =1 Not available = 0	
• People present	Almost always= 2/Usually=1 /Not = 0	
• Street lighting	Number of street lights	
• Street access control	Number of street access controls within buffer	
• Signal coverage	The total number of pedestrian signals	
• Traffic volume and speeds	Average speed of the vehicles within buffer	
• Safety from crime	Number of CCTV cameras within buffer	
• Crossing facilities	The total number of pedestrian crossings	
• Company (Walking with another person or a pet)	Yes = 1 No = 0	
6. Weather		
• Preferred time to walk	Daytime= 1 Night time= 0	Nankervis, M., (1999), Saelens, B., Sallis, J., & Frank, L. (2003)
• Will rain matter?	Yes = 0, No= 1	

Source- Compiled by author

3.0 Methodology

The above thirty factors of built environments that affect walkability in urban neighborhoods were identified as indicated in table 1. The time spent on walking to work and other places during a week was calculated considering the time walked to each of those places and to the nearest bus terminal to go to work daily. The total time spent for walking during a week is considered the dependent variable, while the above identified thirty factors are considered as independent variables of walkability of people. The data related to 20 factors of categorical independent variables and 10 factors of continuous independent variables was collected through the tools of a questionnaire survey, direct interviews and a field observation survey.

The land use variation was examined using ‘entropy’ within a 100m buffered circle of the selected thirty five houses. “Entropy” was calculated using the formula developed by Cervero and Kockelman (1997) to assess the similarity of the proportion of land use of the area in parcels reserved to retail, residential, institutional, office and other purposes.

$$H = -1 \left[\frac{\sum (P_j) * \ln(P_j)}{\ln(K)} \right]$$

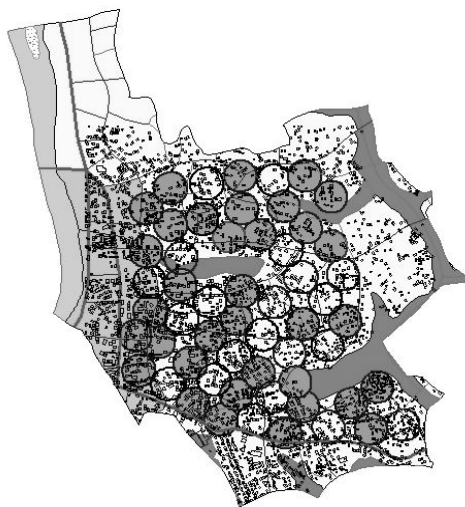
Where: H is the Entropy value. K is the different types of land uses in the buffer. P_j indicates the proportion of land area in the j^{th} land use type and \ln is the natural logarithm using e (approximately 2.718) as its base. Entropy values range between 0 and 1, with 1 representing equal proportion (25%) among the four uses in the neighborhood and 0 representing the presence of a single dominant land use. Table 01 shows that independent variables of bus service, sidewalks, facilities for the disable, places to exercise, accesses to buffer, abandoned or vacant building and having relatives were measured considering the availability inside the 100m buffered circle and the number of intersections, block length, block size, number of street trees and number of traffic calming signals were measured as numerical values.

Chi-square analysis and Bivariate correlation analysis were applied to identify the factors that affect walkability most in the selected case study area. The Chi-squared test was the statistical test used to compare observed data with expected data obtained through a specific hypothesis (H_0 = Two categories of data are independent). In addition, the Chi-squared test was used to find the relationship between the level of walkability and other dummy variables. Bivariate Correlation analysis tests whether the relationship between two variables is linear or not. Bivariate correlation analysis was used to describe the relationship between the level of walkability and the factors affecting walkability which are not categorical. The correlation of each factor to the level of walkability was identified as weak or strong according to the strength of relationship.

4.0 Case study and Data Analysis

The area selected for the case study was the Panadura town which belong to the Panadura Urban Council and is located about 32 km south of Colombo City on the western coastal belt of Sri Lanka. According to the 'Sustainable Colombo Core Area Project (SCCP II)' done by UN-Habitat has identified residential (402.64Ha) is the main land use pattern while commercial (15Ha), public (31Ha) and Industrial (17.75Ha). As evident from the above fact, residential land uses dominate the activity pattern of the city. Litman (2010) stated that it is more likely to walk through a shorter distance like 100m, while a longer distance requires a combination of walking and usage of public transport. This walking link is often ignored if a motorized link has taken place on public. Therefore, buffered circles of a radius of 100m were drawn around 56 randomly selected houses in the Panadura urban neighborhood excluding the arterial and city center. Accordingly, 35 out of the 56 buffered circles were selected using a systematic sampling technique for conducting a questionnaire survey, interviewing the owner of the randomly selected house in each buffered circle. Figure 1 shows the sample of buffered circles selected from the neighborhood. The data on age, gender, race/ethnicity, family income, and education level of each respondent were examined during the questionnaire survey. Just over half of the sample size (60%) was women and most of the respondents' ages were between 40–59 years. Out of the total 35 buffered circles, 23 buffered circles provided entropy values close to 0 which emphasizes the fact that the homogeneous land use character of the area predominantly being residential. There is a good road network all over the area of Panadura. Out of 35 buffered circles, 6 buffered circles were recorded with the facility of good side walk and 97% of the area of the neighborhood was facilitated with street lighting.

Figure 1: Selected sample buffered circle from the neighborhood



Source- 1:10,000 Digital data base, Survey Department, Sri Lanka

The main objective of this study was to identify the most significant factors of the built environment that affect the walkability of people in the Panadura neighborhood area. Accordingly, 20 categorical variables were correlated with two

categories of walking time (0-175minutes & 176- 350 minutes), using the Chi-squared analysis and 10 continuous variables were correlated with the continuous variable of walking time using bivariate correlation analysis. The Chi-squared analysis reveals that relatives within a buffer (4.610, 0.032), availability of undesirable lands (4.610, 0.032) and the availability of people in streets (9.927, 0.042) are the factors which show significant dependence on walking time. The Bivariate correlation analysis shows that block length (-0.412*, 0.014) and the number of street lights (0.369*, 0.032) are the variables which show significant correlation (significant level = 0.05) with walking time.

5.0 Conclusion

Although many previous studies identified a relationship between different factors of the built environment and the level of walkability, this interdependence is poorly understood in urban planning in Sri Lanka. The findings of this study indicate that the block length, the number of street lights, availability of relatives within a radius of 100m of the buffered area from their residence, availability of undesirable lands and the number of people found in streets are the most significant factors of the built environment in the Panadura urban neighborhood that affect the level of walkability in the area. In planning a walkable city with a sustainable transport system, planners should be concerned on the factors which play a major role in enhancing the level of walkability in different contexts and encourage walking either to attend to diverse needs or man-made or natural environment that facilitates walking.

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Cost Benefits of Steel compared to In-situ Concrete in Sri Lankan Building Construction

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Abstract

Ever increasing building construction activities involve high technologies and innovations to overcome the challenges in front of the process. Among the key challenges of building construction, cost of construction is prominent. However the construction industry constantly experiment innovative solutions which may offer favorable cost benefits for building construction. Most of developed countries draw attention on material-wise solution together with better administration and co-ordination within construction environment. Concerns on steel as a cost effective material for construction is one of an ideal example which suggested having the ability to offer better answers for future construction challenges. Steel buildings are designed, fabricated and constructed to meet the needs of the customer and to be cost effective. With steel construction, delays in construction are less, and unexpected costs that often associated in traditional constructions are reduced or eliminated. Properties of steel and vantages of steel construction also have been influenced in erection of steel structures such as skyscrapers, high-rise building and other small buildings in the developed countries. Future adaptability with easy connection systems, minimum waste, long life, reduced disruption at sites, suitability for confined sites are some benefits of using of steel as the main construction material. Eventually, above-mentioned benefits of steel will be afforded indirect cost benefits of steel building construction.

The aim of this research is set as to identify the cost benefits of steel building construction in terms of factors of production in Sri Lankan construction industry. In achieving the above aim the method followed comprises of a comprehensive literature survey followed by a questionnaire survey. Data collection was done through the questionnaire survey to gather expertise knowledge and experiences of professionals in the industry. Through the questionnaire, related cost influence factors of production were compared between steel and in-situ concrete construction. Questionnaires were distributed among 44 construction industry professional and received 30 responses. The collected data was analyzed using RII, binomial test and median and approach to two major outcomes. Cost factors were identified which were offered cost beneficial and not cost beneficial separately in steel building construction compared to in-situ concrete building construction. It was found out that labour, material related costs are beneficial factors of steel construction over in-situ construction. In-situ construction is ahead of steel in terms of cost benefits in the areas of land, standards and technologies related cost factors whereas maintenance cost shows no significant difference. Therefore it can be concluded that steel construction offers cost benefits over in-situ construction as labour and material contributes to a higher proportion of project cost.

Keywords: Buildings; Cost Benefits, Sri Lanka, Steel Construction,

1.0 Introduction

Building is one of the most important activities in any economy and it consumes a large amount of national resources for the construction and maintenance of buildings (Stone, 1983). Building construction needs ordered and planned assembly of materials, which are assembled at outdoors through a large number of diverse constructions. Therefore, Building construction is a complex process with its unique characteristics (Mehta, Scarborough, & Armpriest, 2008).

The proper selection of materials can influence the cost of construction, maintenance cost, durability and its appearance. Materials, which are used to construct structural elements of the building, are in wide varieties. Woods, concrete and steel are commonly used construction materials in many parts of the world because of their inherent properties of construction (Mrema, Gumbe, Ghepete, & Agullo, 2011).

Steel is increasingly becoming a more popular material for building construction in recent years and uses as a major construction material in building construction for most of structural elements in buildings. Abesuriya (2007) stated “the common structural form of a multi-story steel building consists of steel H sections as columns, wide flange sections or I

sections as beams, and concrete floors” (p.22). In addition, Abesuriya (2007) mentioned that walls could be block, brick or glass curtain walls for facades of buildings. Therefore, steel buildings are normally constructed as composite buildings, with the involvement of number of various construction materials (Panchal, 2010).

Steel buildings are designed, fabricated and constructed to meet the needs of the customer and to be cost effective. With steel building construction, delays in construction are less, and unexpected costs that often associated in traditional constructions are reduced or eliminated (Noton, 2010).

There are some landmark steel buildings in the world, such as the Empire State Building, which is the tallest of buildings in New York (Post World Trade Centre). Its height is 381m and is currently functioning as an office building. Contractor have been managed to build this steel framed structure in a record time (thirteen months). The Aon Centre building is the third tallest among all-steel buildings in the world which is located at Chicago. There are some more to be given as examples for popular use of steel material as, John Hancock Centre Chicago high-rise office building and Minsheng Bank building China with 68 floors (ITP Business Publish, 2010) being some good example.

Properties of steel and vantages of steel composite construction also have been influenced in erection of steel composite structures such as skyscrapers, high-rise building and other small buildings in the developed countries. Steel Framing Alliance (2013) reported that steel is considered as a green material because of its recyclable ability. According Abesuriya (2007) Report of Annual Transaction of Institute of Engineers Sri Lanka (IESL) the construction time can be reduced with pre-fabrication and erection method of steel construction and higher quality can be maintained. Future adaptability with easy connection systems, minimum waste, long life, reduced disruption at sites, suitability for confined sites are some benefits of using of steel as the main construction material in steel construction.

As explained, unlike Sri Lanka, steel composite building constructions are famous in intentional construction industry. Because of that, steel composite construction benefits as a material and in construction operation at the site. Eventually, above-mentioned benefits of steel building construction will be afforded indirect cost benefits in composite steel building construction.

1.2 Problem Statement

The pre-fabricated steel or turnkey type buildings will be the future in the world construction industry with the ever-increasing building materials cost and the time consuming factor. In addition, the strength and durability of steel as a construction material is well known and these qualities also help reducing the cost of steel buildings by ensuring the longevity and sustainability of such structures (Tuknov, 2012).

However, there are less numbers of steel building constructions in Sri Lankan construction industry while steel building constructions are well known worldwide due to its above-mentioned benefits. Therefore, it is important and vital study whether steel building construction is economical in Sri Lankan construction industry.

Cost effectiveness of steel building construction need to be considered based on land, labour, capital and entrepreneurship that are being the factors of production in construction industry (Colaner, 2008). The factors of production will define the total cost of the products. Therefore, the cost benefits present under these categories would be leading steel into a conclusion that steel as a cost beneficial material in the construction. With such background, the research considers it as an important study to do some scientific investigation to check steel building constructions as a cost beneficial solution for Sri Lankan building construction.

1.3 Aim

Based on the background study, the aim of this research is to identify the cost benefits of steel building construction in terms of factors of production in Sri Lankan construction industry.

1.4 Objectives

- Explore different cost aspects under the four factors of production in construction of building.
- Identification of factors affecting to the cost, related to factors of production in building construction.
- Compare the cost aspects of steel building construction with in-situ concrete construction.
- Identify steps to reduce the construction cost through usage of steel in building construction.

2.0 Literature Review

2.1 Introduction to Steel Building Construction

Composite steel construction are falling into two categorize as “composite steel and concrete building construction”, and “composite steel building construction”. Composite steel and concrete building construction is a type of steel building construction done with structural members who formed bonding concrete components to steel member (Ellobody & young, 2010). Whereas, composite steel building construction considers steel as the main construction material and some elements of the building are constructed out of different material such as brick or block masonry for walls, precast concrete units for slabs and in-situ concrete for foundations (Abesinghe, 2007). This research “benefits of steel composite building construction” explores the benefits of composite steel building construction (hereinafter the term “steel building” is used for “composite steel building” construction).

The structural frame of a steel building is constructed by assembling prefabricated steel components at site. Structural steel sections such as I beams, H sections , angle irons, circular and square hollow sections etc, have been used widely in the global building construction industry (Abysinghe, 2007). A unique feature of steel building structure is that the assembly details. Details of the connections between steel components are not prepared by architecture or structural engineer, but done either by independent detailing company or by an in-house outfit of a steel fabricator (Mehta, Scarborough & Armpriest, 2010). Therefore with such unique characteristics it could be hypothesized that steel building construction would have provides different and strong benefits to the construction project.

2.2 Structural framing construction process

Nunnally (2007) stated that structural framing construction is the most significant part of the steel building construction. Therefore structural framing construction process is a well-established planning assembly process with the several distinct stages. They are identified in steel building constructions process given as in Figure 1.



Figure 1:
Steel building frame construction process
 Source: (Mehta, Scarborough & Armpriest, 2010)

Preparation the preliminary layout involves careful integration of structural consideration with several nonstructural considerations, such as HVAC, the building envelop, fire resistance, interior finishes, aesthetic, and cost. Unlike masonry and site cast concrete construction, structural steel components are brought to the site in a prefabricated and finished state, ready for erection and assembly. Detailing should be done in the most economical manner and in a way which is best suited for the erection, scheduling, and the condition of the site. Fabrication of steel components included cutting plates and angles to the required size, punching plates and angles, drilling holes of the required diameters and spacing. The erection of the structural steel frame at the site may be performed by the fabricator or by a separate erection company. In most cases, the general contractor will seek separate bids for fabrication and erection. Fabricator and erector can be selected on the basis of a competitive bid (Mehta, Scarborough & Armpriest, 2010; Nunnally, 2007).

2.3 Relationship between Steel and In-situ Construction Cost and Factors of Production

According to economics theories, factors of production are the inputs of a product or a service namely land, labour, capital, and entrepreneurship. These factors determine the final cost of a product or a service in any industry (Colander, 2008). In the construction industry, cost of each factors of production can be illustrated with regard to different aspects in different steps involve in a process.

Land cost is comprised the cost of all natural resource which are used in production, including non renewable and renewable resource and land itself. Labour cost, includes cost of all working people ranging from the unskilled worker to the most highly trained workers. Capital cost includes the cost of all the manufactured inputs for the construction

process such as machinery, material together with indirect cost. Entrepreneurs are individuals who are prepared to take risks and manage all above three factors of production inputs (Cooke, 1996).

The construction cost of building may be varied according to method of construction. The identical factors of production are subjected to cost comparison with the cost significant factors in the building construction process. This cost comparison in relation to steel and in-situ is based on Standard Method of Measurement (SMM7) work sections for the buildings. Building construction works are classified in element wise in the SMM7 as earth work, foundation, column/beam, slabs, roof, walls, finishes and service installation.

2.3.1 Land

Land plays a significant role in building construction that determining the ultimate cost of the construction output. Figure 2 shows the cost accumulating factors in building construction process with regard to land.

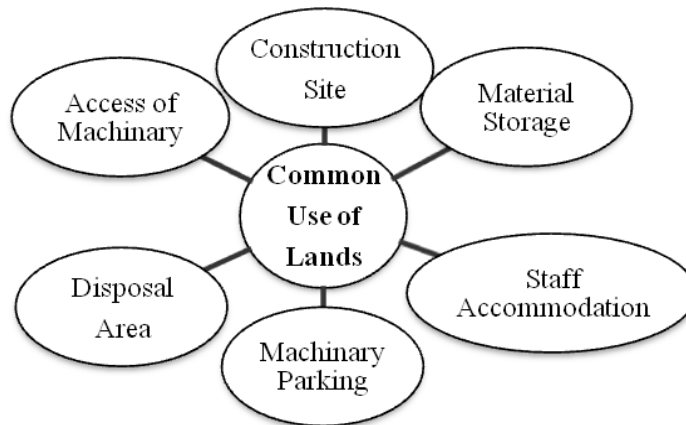


Figure 2: Common use of land with regard to construction project

Source: (Harvey and Jowsey, 2004)

Above factors are influencing the ultimate cost of the construction output. The final product cost will be changed according to the type of construction (Stone, 1983). Therefore, construction methods (whether its steel building construction or in-situ concrete building construction) would be having different land cost influences due to above factors.

Major cost adding and deducting factors related to land in the steel building construction process is recognized in the Figure 3. The factors of land are identified comparatively to the in-situ concrete construction process. Cost “Deducting” factors are represent cost saving and “Adding” factors are the additional cost of the steel building construction process.

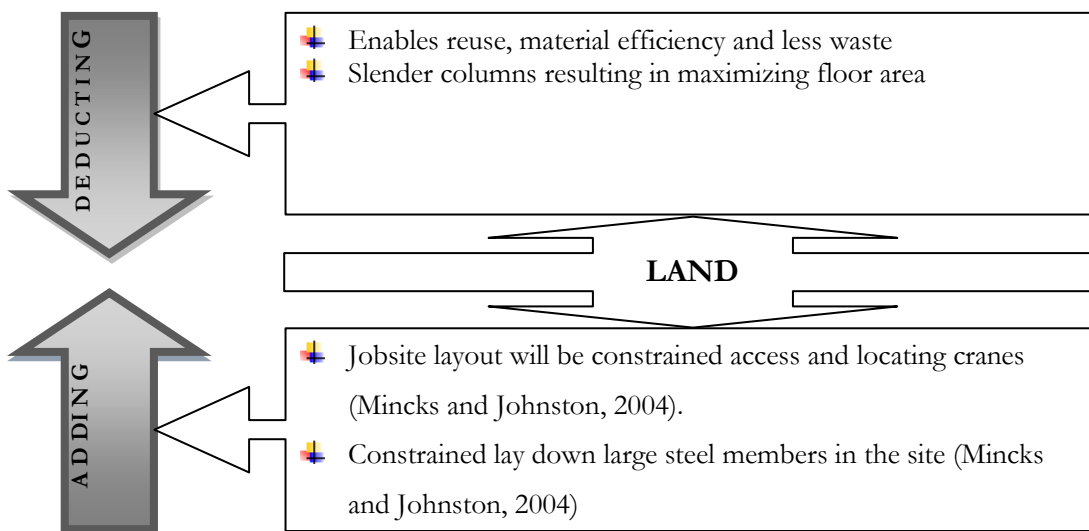


Figure 3: Cost components comparison of land

2.3.2 Labour

“Labour” is a highly cost significant factor in a construction project (Briscoe, 1988). Popescu, Phaobunjong and Ovararin (2003) stated that “ the labour cost component of a construction project often ranges from 30% to 50%, and can be as higher as 60% of the overall project cost”(p108). Pricing labour is one of the most difficult tasks in cost estimate, as pricing labour involves high number of variables to be in concern. It is also a subjective factor in cost estimating unlike pricing materials or equipment (Briscoe, 1988). Further, there is a high involvement of labour gangs which are specialized in performing in different construction trades. Each group under any category would be having different cost influences to the project. Major cost adding and deducting factors of labour in the steel building construction process is recognized in the Figure 4. The factors of labour are identified comparatively to the in-situ concrete construction process.

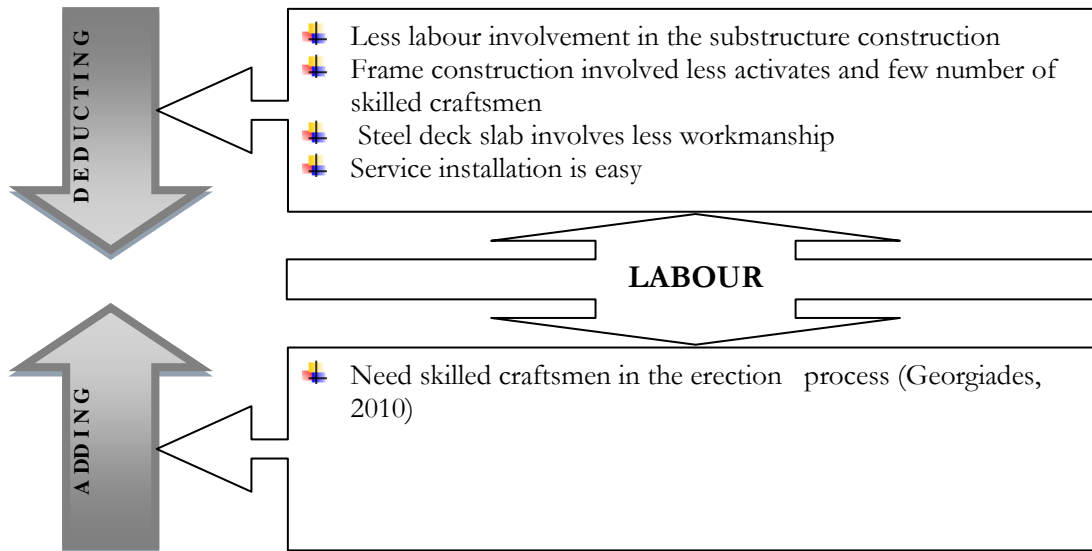


Figure 4: Cost components comparison of labour

2.3.3 Capital

There are three major categories of capital good in the construction industry as structures and overhead, equipment and inventories of inputs. Structures and overhead cover construction firms, accommodation buildings, job site personals etc. Equipment is the durable goods like automobiles, tools and computers and capital are the capital items inventories of inputs such as material use for the construction. Frequently firm use their own capital goods but some capital goods have to be rented in externally (Nordhaus, 2005).

Cost of materials

Material is a high cost significant input of the construction industry. Material cost related attributes in each construction technologies are given in Table 1.

Table 1: Material cost accumulation components

Element	Steel building	In-situ concrete
Foundation (eg:-shallow foundation)	-Concrete, reinforcement, formwork and Gunny bags -Transportation and Storage	-Concrete, reinforcement, Formwork and Gunny bags -Transportation and Storage material
Beams and Columns	-Steel members, nut and bolts, angles, plates and stabilizers -Detailing steel members -Fabrication members -Handling in each stages -Transportation and Storage material	-Concrete, Reinforcement, Formwork and Gunny bags -Transportation and Storage material

Element	Steel building	In-situ concrete
Slab systems	-Steel decking, concrete, reinforcement -Transportation and Storage material	-Concrete, Reinforcement, Formwork and Gunny bags -Transportation and Storage material

Cost of equipments

Equipment cost rank second after labour costs in construction due to their high involvement in modern construction projects and the unpredictable nature of production of a construction project (Stone, 1983). Equipment can be acquired through three methods purchasing, renting or leasing (Gransberg, Popescu & Rayan, 2006). Machinerics which are used in steel and in-situ building construction process are given separately in the below Table 2.

Table 2: Plants and equipments use in the construction

Element	Steel building	In-situ concrete
Foundation (eg- shallow foundation)	-Poker vibrator -Pump car	-Poker vibrator -Pump car
Beams and Columns	-Tower crane, and man lifts -Mobile crane -Welding plants and generators	-Poker vibrator -Tower crane -Pump car
Slab systems	-Tower crane and, man lifts -Mobile crane -Welding plants, and generators	-Poker vibrator -Tower crane -Pump car

Structures and overhead

Structures and overhead are the indirect cost for the construction work, which is not a directly involving cost component to the construction work at the site. Firm and the temporary site accommodation facilities are considered as structure cost. Rental, taxes and running cost are major cost element of the structures. Overhead cost includes mobilization cost, job site personal cost and cost for the site utilities (Smith & Jaggard, 2007). Cost attributes of structure and overhead of the two types of construction are presented in Table 3 (Steel frame vs. In-situ concrete building).

Table 3: Cost components of structures and overhead

Construction stage	Steel building	In-situ concrete
Bonds	-Bonds, insurance, permits -Taxes required in the contract general conditions	-Bonds, insurance, permits -Taxes required in the contract general conditions
Mobilization	-Field buildings -Horizontal structures (roads, parking, fences, and gates)	-Field buildings -Horizontal structures (roads, parking, fences, and gates)
Job site personals	-Wages and fringe benefits -Project related travel expenses	-Wages and fringe benefits -Project related travel expenses
Construction period	-General use equipment (eg:- crane, hoist) -Site utilities in job duration -Whether protection of completed works or works in progress -Protective aids and safety measures for workers	-General use equipment (eg:- crane, hoist) -Site utilities in job duration -Protective aids and safety measures for workers

Major cost adding and deducting factors of capital in the steel building construction process is recognized in the Figure 5.

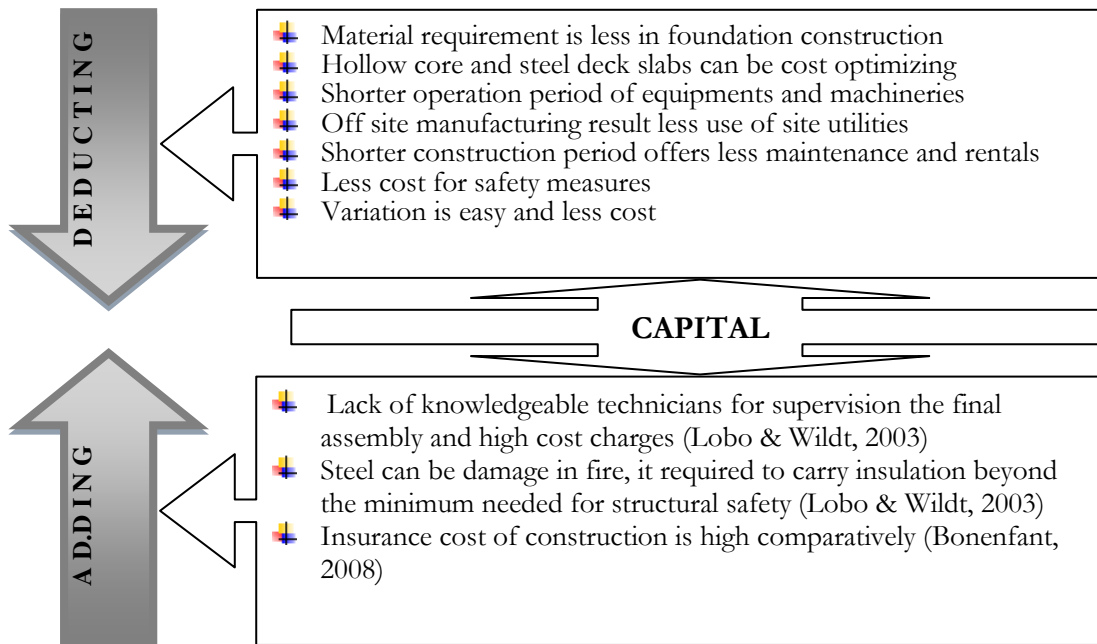


Figure 5: Cost components comparison of capital

The factors of capital are identified comparatively to the in-situ concrete construction process.

2.3.4 Entrepreneurship

Construction entrepreneurs are significantly involving various ways in the construction industry and take many directions and field into construction such as sustainable construction entrepreneurs or by working more on the design side as an architect entrepreneur (Burke, 2011).

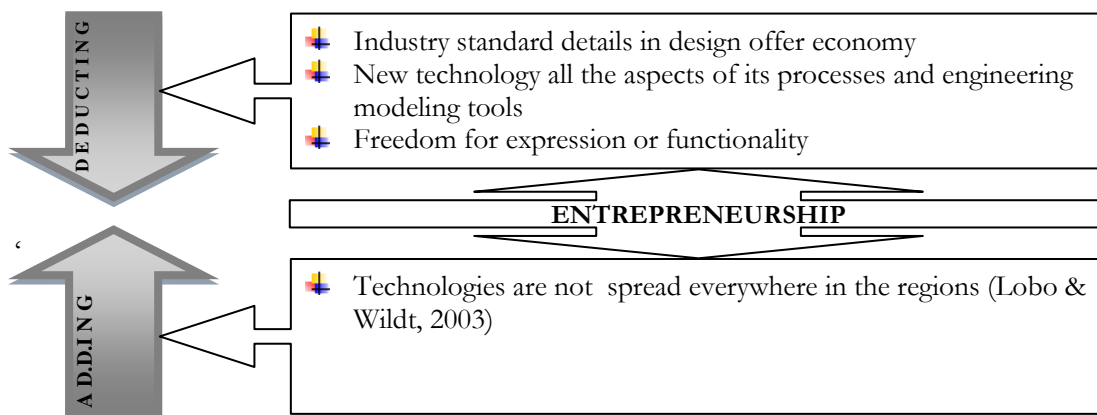


Figure 6: Cost components comparison of entrepreneurship

Burke (2011) and Hedley (2013) stated that the construction industry entrepreneurs are involving several areas. They are suppliers of innovations based on various technologies to the construction industry. Construction entrepreneurs innovates successful experimentation, development and introduction of new products, processes, combinations, services or organizational forms. Further entrepreneurs have the ability to be scaled up to change or replace current practices in the sector which results in reduced deterioration of the human environment and natural resources while at the same time retained or improved economic competitiveness. Major cost adding and deducting factors of entrepreneurship in the steel building construction process is recognized in the Figure 6. These factors of entrepreneurship are identified comparatively to the in-situ concrete construction process.

2.4 Best Practices to Reduce Steel Building Construction Costs

There are many potential economies to using a structural steel frame. Economy begins with an efficient design and layout by the structural engineer, and can be maintained or increased during fabrication and erection by careful coordination and communication by all parties. Site layout and construction sequencing will influence equipment

requirements and cost, as well as the speed of erection. The cost reduction factors are discussed under the design stage and construction stage below.

Design stage

In construction management, design-build project delivery methods, the steel contractor may be in a position to provide early input into the design, which may lead to design that is more economical. The quality of the contract documents has a significant impact on the ability of the estimator to determine precisely what is required for the project. Incomplete or poor detailed planes require the steel contractor's estimator to guess at the designer's intentions. To be protected from risk of future modifications or (bulletins), the estimator will naturally increase the price (Mrozowski, Syal & Kakakehe, 1999).

Construction stage

Following list of cost-saving measures can be practiced in the steel building construction process. These measures provide more efficient construction environment in the steel building construction process.

The specification of special coatings will add significant cost to the project. Preparation of the surface, painting, handling, and paint touch-up, are all increased by the use of special coatings. Where architecturally exposed steel is to be used on the project, these coating may not be avoidable. However, fabricators should be consulted during preparation of specifications to determine the appropriate coatings and their ability to apply them. When steel is to be completely enclosed, painting may not even be necessary (Mrozowski, Syal & Kakakehe, 1999). Site layout and configuration, as well as construction sequencing, are important elements in establishing the type of equipment and the time required to erect the structure. Close coordination by the erector, fabricator, and contractor in project planning for construction can increase the efficiency of the erection crew and consequently reduce erection costs. Avoid connections which require extensive field welding when possible. When the design is such that field welding is necessary, connections should be designed to avoid awkward or overhead welding angles. Steel shapes, which have cost premiums, should be avoided when possible. Some structural shapes, such as bent and tees require fabrication to achieve the shape. The use of angles instead of bent plates may save project costs (Mincks & Johnston 2004).

3.0 Research Methodology

This research falls in to post positivism paradigm philosophically. Therefore survey approach was most suitable to achieve the research objects. The simple random sampling method was adopted to select sample from the population. The professionals who have experienced in steel building and in-situ building construction practices were the population of the research. These professionals should have knowledge and understanding in steel building and in-situ building construction practices and cost aspects of processes. Therefore the professional quantity surveyors and engineers were belongs to the population of this research. The questionnaire survey was implemented with thirty professionals using a respond scale.

The collected data was analyzed using descriptive statistics analysis methods, relative important index (RII), binomial test and median. MS-Excel computer base software was used to calculate the RII value. This has been identified as a data analysis technique in order to rank the factors and identify the most significant factors. The binomial test shall be used at the circumstance of dealing with nominal categorical data and the population may be classified only into two categories. If the probability of obtaining an element is being "p" probability of second sample shall be "1-p" (q) in this type of data distribution. The null hypothesis (H_0) shall be rejected if calculated probability is small than $\alpha = 0.05$. Median is the best method to ordinal data analysis which is concern on distribution of data set. The data were to be presented in graphical manner using Microsoft offices excel.

4.0 Research Findings and Discussion

4.1 Respondents Details

Questionnaires were distributed among professional quantity surveyors and engineers who engaged in building construction works, where they were randomly selected from consultancy and contracting organizations. Response rate was 68%. According to the responses categorization consultants and contractors organizations are represented respectively 33% and 67%. Among them 27% were Engineers and Quantity surveyors were 73%.

4.2 Identification of Cost Benefits of Steel Building Construction

It is a query whether the cost benefits exist in steel building construction in the Sri Lankan construction industry. Among the collected questionnaires 87% of them were responded as steel building construction is cost beneficial material in building construction and 13% responses as in-situ concrete building construction is cost beneficial. Mover over the collected data from this section shall be tested for the population using binomial test. Sample probability of cost benefits of steel is 87%. According to sample probability steel building construction can be considered as cost beneficial as it is more than 50%, which is the critical value. Even though collected data set should be tested for population, where Binomial test can be applied because which is nominal categorical data analyze method.

4.5 Comparison of Importance of Identified Cost Factors in Steel Building Construction Compared to In-situ Concrete Building Construction

Respondents were given their responses comparing each cost factors (CFs) and marked in the response scale of the questionnaire provided. RII values of 23 CFs for steel (X) and in-situ (Y) building construction were calculated using the collected responses. Thereafter, the cost factors are ranked base on RII value difference (X-Y) as given in Table 4.

Table 4: Respondents' relative importance index (RII)

No	Cost Factors (CFs)	RII			Rank
		Steel (X)	In-situ (Y)	Deference (X-Y)	
1	Labour cost involve in the substructure construction	4	37	-33	2
2	Labor cost involve for the frame construction such as beam, columns and satire ways	7	35	-28	3
3	Labor cost involve of slab construction process	11	33	-22	6
4	Labour cost involve for the service installation	4	22	-18	7
5	Material cost of the foundation construction process	9	31	-23	5
6	Material cost for frame construction process (eg:- column and beams)	34	8	26	21
7	Material cost for slabs construction process	10	25	-15	8
8	Operational cost for equipments and machineries in the construction	16	21	-5	12
9	Cost of site utilities in the construction period	10	24	-14	9
10	Maintenance cost and rentals of site offices and other temporary buildings	7	33	-26	4
11	Cost for consideration of safety measures in the site construction process	17	11	6	17
12	Cost for provision of changes and variation in the construction process	10	21	-11	10
13	Cost for providing insurance for the construction works	16	11	5	15
14	Cost allocation for price escalation	10	19	-9	11
15	Cost allocation for risk in the construction	27	9	17	19
16	Cost for finding the industry standard details in design	19	15	5	14
17	Cost for technological aspects of its processes and engineering modeling tools	25	11	14	18

18	Cost for expression functionality and aesthetic of design	14	15	-1	13
19	Cost for find available technologies in the regions	32	4	28	23
20	Land cost for access and handling heavy machineries	13	7	6	16
21	Land cost for the material storage and lay down in the site lay out	27	6	21	20
22	Cost of maintenance the building	29	3	26	22
23	Cost of demolition and removing debris	4	45	-41	1

Sum of RII (X-Y) is calculated deducting RII value of steel (X) from in-situ (Y). Factors which have high cost for in-situ concrete building construction they become high negative RII values, likewise factors which have high cost for steel building construction, they become large positive RII values as shown Table 4.

4.5.1 RII analysis

Relative importance index (RII) was calculated for each cost factor in the section separately for steel building construction (X) and in-situ concrete building construction (Y) in the Table 4. These RII values shall be plotted to acquire following Figure 7 against rank of RII value difference.

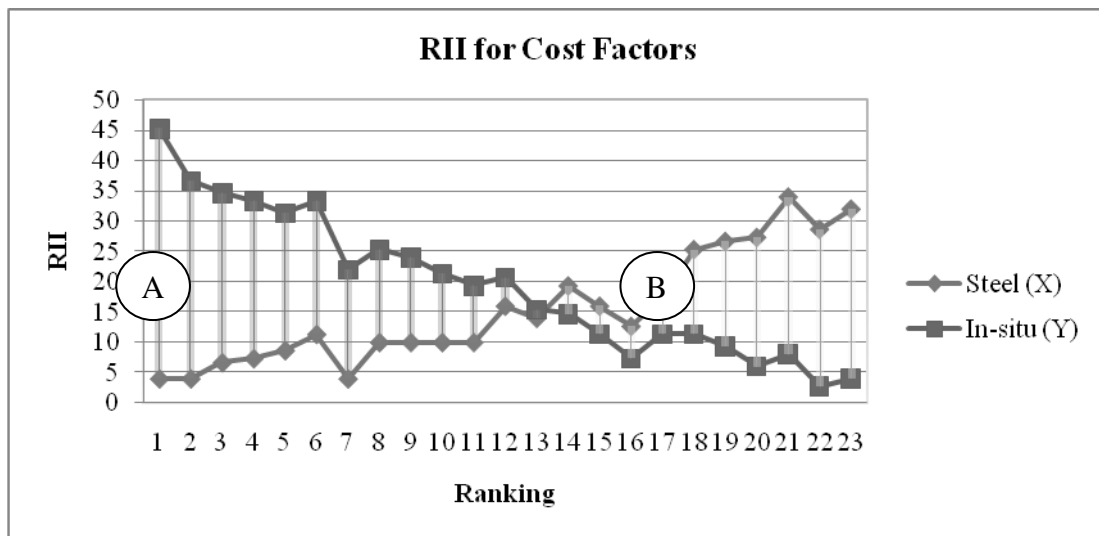


Figure 7: Steel (X) and in-situ (Y) RII values for cost factors

Blue and Brown colored lines are representing respectively RII values of steel and in-situ building construction against ranked cost factors. Green colored hatch area (A) is represented that RII value of in-situ is larger than steel and yellow (B) colored hatch is presented that RII value of steel is larger than in-situ. According to the Figure 7 green colored hatched area is larger than yellow colored area (A>B).

RII value is representing comparative cost of each factor given at Table 4. If RII value increases for a particular side comparative cost of a CF will be increased. The first (1) ranked CF which is demolition and removing debris has less RII value for steel building construction side compared to in-situ building construction side according to Figure 7. Therefore this factor having high cost for in-situ building construction compared to steel building construction. RII value of steel building construction factors are regularly increasing according to blue color line in Figure 7. However, it is not exceeding the brown colored line up to 13th ranked CF which is functionality and aesthetic of design. After that CFs have greater cost for steel compared to in-situ building construction.

4.5.2 Construction cost factors analysis by median

The middle value of data distribution will be taken as median when data set established in ascending or descending order. Here thirty (30) respondents have been considered for analysis. According to the number of respondents, median can be taken as the 15.5 position of the data set however that position cannot be interpreted. Therefore

response weightage value is taken relevant to 15th and 16th (fifteen and sixteen) positions as particular median of each CF. Medians were calculated using MS office excel computer base software.

Median analysis for labour related cost factors

Labour intensive cost factors are separately considered their responses Table 5 with their median position by highlighting. Microsoft Excel spread sheet was used to represent the responses in Table 5. Conditional formatting was emphasized and visualized highlighting median position for each question.

Table 5: Labor related cost factors

No	Cost Factors (CFs)	Steel					In-Situ					
		Very High Cost	High Cost	Moderate Cost	Low Cost	Very Low Cost	Not Consider: Very Low Cost	Low Cost	Moderate Cost	High Cost	Very High Cost	
1	Labour cost involve in the substructure construction				2	2	3	5	9	6	1	2
2	Labor cost involve for the frame construction				3	4	3	4	6	6	2	2
3	Labor cost involve of slab construction process			2	5	1		4	12	3	2	1
4	Labour cost involve for the service installation				1	4	6	9	6	4		

It is seemed that all the labour related CFs are costly in in-situ concrete building construction compared to steel building construction. The first factor, labour cost involvement in the substructure construction is costly for in-situ building construction according to the median position in Table 5. The second CF is the labour cost involves for the building frame construction which also have lower amount of high cost for in-situ building construction compared with steel building construction. Labour cost for slab construction and service installation are again costly in in-situ concrete building construction according to Table 5.

Median analysis for material and plant related cost factors

Material and plant incur high cost in building construction. Therefore the cost belongs to material and plants have been denoted under four CFs (Table 6) which may significant cost differences in steel and in-situ building construction process. Steel construction process is attentively distinguished and compared in terms of material and plant related cost factors with in-situ concrete building construction in the Table 6.

Table 6: Material and plant related cost factors

No	Cost Factors (CFs)	Steel					In-Situ					
		Very High Cost	High Cost	Moderate Cost	Low Cost	Very Low Cost	Not Consider: Very Low Cost	Low Cost	Moderate Cost	High Cost	Very High Cost	
1	Material cost of the foundation construction			2	3	1		9	11	2		2
2	Material cost for frame construction process	1	4	4	5	8		4	4			
3	Material cost for slabs construction process			1	4	4	4	3	10	2	1	1

4	Operational cost for equipments/ machineries in the construction			2	6	6	1	7	4	1	2	1
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Material cost of the foundation construction has two median positions shown as Table 6. However both median indicates that in-situ building construction have very low to low amount of high cost for this CF compared to steel building construction. The second (2nd) CF material cost for frame construction in the Table 6 steel side has high rate of responding. Furthermore its median position located in the steel side. Therefore steel have very low amount of high cost compared to in-situ building construction.

Material cost for slab construction again little bit more in in-situ building construction compared to steel building construction. Final CF, operational cost for equipments and machineries of Table 6 is appeared multiple medians such as “not considerable cost” and “very low cost”. However exact median should be located in between 15th and 16th position of data distribution therefore it should be costly even marginally for in-situ building construction compared to steel building construction.

Median analysis for site utilities and overhead related cost factors

Incurring cost due to construction utilities and overhead have been considered for comparison between steel building constructions with in-situ concrete building construction in the industry. Median values of each CF have been shown in Table 7 below.

Table 7: Site utilities and overhead related cost factors

No	Cost Factors (CFs)	Steel					In-Situ					
		Very High Cost	High Cost	Moderate Cost	Low Cost	Very Low Cost	Not Consider: Very Low Cost	Low Cost	Moderate Cost	High Cost	Very High Cost	
1	Cost of site utilities in the construction period				6	3	3	6	7	4	1	
2	Maintenance cost and rentals of site offices and other temporary buildings				4	3	5	1	6	8	2	1
3	Cost for consideration of safety measures in the site construction process			2	6	8	3	5	6			
4	Cost for provision of changes and variation in the construction process			1	4	4	3	8	6	4		
5	Cost for providing insurance for the construction works			1	8	5	4	7	5			
6	Cost allocation for price escalation			1	5	2	6	9	3	2	2	
7	Cost allocation for risk in the construction	1	1	4	7	5	2	6	4			

Site utilities, maintenance of temporary building, provision of changes and cost allocation for price escalation named CFs (1st, 2nd, 4th, and 6th) have median at the side of in-situ as Table 7 therefore these CFs are costly for in-situ building construction compared to steel building construction. Furthermore there is trend of responses towards right side furthermore most respondents have been determined that this CFs are costly in in-situ concrete building construction compared to steel building construction. However steel building constructions is costly for safety measures and consideration of risk in the construction (3rd, and 7th CFs) with compared to in-situ building construction. Cost for providing insurance for the construction works, neutral response is gained by the median analysis according to result this CF will not affect the method of construction.

Median analysis for standards and technologies related cost factors

Standards and technologies are essential for most of the areas of building construction. Table 8 represents the standards and technologies related cost factors of building construction as well as the relevant responses of steel and in-situ building construction process. The highlighted values are the median/medians of each CFs.

Table 8: Standards and technologies related cost factors

No	Cost Factors (CFs)	Steel					In-Situ					
		Very High Cost	High Cost	Moderate Cost	Low Cost	Very Low Cost	Not Consider:	Very Low Cost	Low Cost	Moderate Cost	High Cost	Very High Cost
1	Cost for finding the industry standard details in design		1	2	7	5	1	6	8			
2	Cost for technological aspects of its processes and engineering modeling tools			5	10	3	1	5	6			
3	Cost for expression functionality and aesthetic of design			2	6	3	2	12	4	1		
4	Cost for find available technologies in the regions			6	11	8	2	1	1	1		

Cost for finding the industry standard and details in design have multiple median according to Table 8. In accordance with, median should be in between “very low cost” or “not considerable cost”. However this particular position is side of steel according to the median, therefore first CF is costly in steel building by a construction from least amount compared to in-situ concrete building construction. The next CF which is cost for technological aspects of its process and engineering modeling tools also has multiple medians in Table 8. However it is costly in steel building construction compared to in-situ building construction. Cost for expression functionality and aesthetic is costly in in-situ building construction compared to steel building construction. More responses of final CF in the Table 8 trend to side of steel building construction likewise its median also side of steel. Then the CF can be considered as costly in steel building construction compared to in-situ building construction.

Median analysis land related cost factors

Land related cost factors shall be listed out as following Table 9. Furthermore comparative responses can be seen in steel and in-situ building construction techniques. Land cost for handling materials and heavy machineries shall be costly in steel construction. Furthermore, most of professionals’ responses are side of steel. Then above CFs are costly in steel building construction compared to in-situ building construction process.

Table 9: Land related cost factors

No	Cost Factors (CFs)	Steel					In-Situ					
		Very High Cost	High Cost	Moderate Cost	Low Cost	Very Low Cost	Not Consider:	Very Low Cost	Low Cost	Moderate Cost	High Cost	Very High Cost
1	Land cost for access and handling heavy machineries			1	2	13	6	5	3			
2	Land cost for the material storage and lay down in the site lay out			4	7	15		1	1	2		

Median analysis of cost factors after construction

The most significant cost factors which may affect to the life cycle cost of construction have been analyzed in Table 10 below.

Table 10: Cost factors after construction

No	Cost Factors (CFs)	Steel					In-Situ					
		Very High Cost	High Cost	Moderate Cost	Low Cost	Very Low Cost	Not Consider:	Very Low Cost	Low Cost	Moderate Cost	High Cost	Very High Cost
1	Cost of maintenance the building	1	2	3	5	11	4	4				
2	Cost of demolition and removing debris				1	4		4	8	6	5	2

Building maintenance is essential for effectively functioning the building throughout its life time. Further it’s incurring considerable cost where building owner constantly expected to minimize within the life time of the building. However according to median steel is costly for maintenance of the building representing Table 10.

Demolition and removing debris are difficult and costly at the in-situ construction according to median analysis. More over most responses are side of in-situ for demolition therefore the above statement is further substantiated.

4.6 Reducing Cost of Steel Building Construction

Accordingly above analysis, it has identified that there are factors which have comparatively high costs in steel construction. In order to minimize such costs, following factors are introduced.

Table 11: Factors reduce cost of steel building construction

No	Factors	Importance					Count	RII	Ranking
		Very Low	Low	Moderate	High	Very High			
1	Avoid connections which require extensive field welding when possible	0	0	11	13	6	30	76.67	1
2	The use of repetitive members of the same length and size will allow for easier shop drawing development	0	2	11	13	4	30	72.67	2
3	Close co-ordination by the erector, fabricator, and contractor in project planning for construction	0	3	12	11	4	30	70.67	3
4	Design-build project delivery methods, provide early input into the design	2	10	11	5	2	30	56.67	4
5	Simplification of member connections and attached items such as curtain walls can save costs	3	9	10	6	2	30	56.67	5
6	The quality of the contract documents	4	17	6	2	1	30	46.00	6
7	The use of angles instead of bent plates for the work	7	14	5	4	0	30	44.00	7
8	When steel is to be completely enclosed, painting may not be necessary	11	15	4	0	0	30	35.33	8

According to the Table 11, there are five factors which are significant as per to RII analysis (>50%). Avoidance extensive field welding is the highest important factor in order to reduce steel construction cost. Steel contractors can concern on importance of above factors at pre-contract stage. Application of above factors may depend on client requirements.

5.0 Conclusion and Recommendation

Construction industry is looking for better alternative solution for ever increasing building material prices which directly effects on construction operational and maintenance costs. In-situ concrete has being prominent construction material for building construction in the Sri Lankan context up to recent years. Researcher concerns on steel as an alternative material for building construction. Therefore the researcher's consideration was to determine the cost benefits of steel building construction for Sri Lankan construction industry. However, there are less numbers of steel buildings constructed in Sri Lankan construction industry while steel building constructions was well known worldwide due to its mentioned benefits.

Cost of component of construction was recognized through four factors of production land, labour, material and entrepreneurship. After that cost factors was identified under each factor of production of building construction. Based on the survey results the identified cost beneficial factors from steel construction were identified as Cost of demolition and removing debris, Labour cost involve in the substructure, frame, slab construction process, and service installation, Material cost of the foundation and slabs construction process, Operational cost for equipments and machineries in the construction, Cost of site utilities in the construction period, Maintenance cost and rentals of site offices and other temporary buildings, Cost for provision of changes and variation in the construction process, Cost for providing insurance for the construction works and Cost allocation for price escalation. However, Cost for find available technologies in the regions, Cost of maintenance the building, Material cost for frame construction process, Land cost for the material storage and lay down in the site lay out, Cost allocation for risk in the construction, Cost for technological aspects of its processes and engineering modelling tools, Cost for consideration of safety measures in the site construction process, Land cost for access and handling heavy machineries like Crane, Trucks in the construction site, Cost for finding the industry standard details in design and Cost for expression functionality and aesthetic of design were identified as less costly with in-situ construction.

In order to reduce such related high costs in steel construction the following steps are suggested by the survey; Avoid connections which require extensive field welding when possible, The use of repetitive members of the same length and size will allow for easier shop drawing development, Close co-ordination by the erector, fabricator, and contractor in project planning for construction, Design-build project delivery methods, provide early input into the design, Simplification of member connections and attached items such as curtain walls can save costs, The quality of the contract documents, The use of angles instead of bent plates for the work and When steel is to be completely enclosed, painting may not be necessary.

However these factors are more applicable within Colombo metropolitan area as the research was carried out base on this area. Furthermore research was done for building construction projects. Besides, cost benefits factors of steel building construction were identified comparing cost factors with in-situ concrete building. Here a hypothetical steel building was considered and which was constructed from steel as the main construction material and some elements of the building are constructed out of different material such as brick or block masonry for walls, precast concrete units or steel deck for slabs and in-situ concrete for foundations.

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Dreams Fall Apart: People's Experience of a Development Project in Sri Lanka

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Abstract

Today, "development" has become one of the most influential and dominant concepts among global political and economic discourses. For many scholars the concept of development has become a convincing notion after the Second World War. After sixty years of development, one wonders whether developing nations were able to achieve their targets. In order to examine the link between the hegemonic development discourse and the practice, this study focuses on a particular development project carried out by the renowned NGO, World Vision, in two rural areas in Sri Lanka. I spent a month in Mahakumbukkadawala and Nawagattegama areas to collect data and stories. The study examines the notion of development as adopted by World Vision and how the project has affected the people in these areas. Further, the research demonstrates that development is unique to the place and the people; hence, it is impossible to import, but needs to grow from within the communities and individuals.

Keywords: *Development Discourse; Development Projects; Sri Lanka; People's Experience*

The great promise

Since the late 1940s, "development" has become one of the most influential and dominant concepts in global political and economic discourses (Escobar 1995, 1997; Esteva 1992; Kapoor 2008; Sachs 1992, 2010). The entire non-Western world has pursued development at a national scale. As the "developed" nations - The United States of America and West European states - brag about their achievements, the so-called "developing" nations' struggle to match the former.

Sri Lanka - an island in the northern Indian Ocean, located south of India - is not an exception. Since the country gained political independence in 1948, development has become one of the broadly used terms in Sri Lanka. Since the 1950s, there were many elections and the government shifted several times. All political parties that contested the elections made fashionable promises using buzzwords such as progress, improvement and, ultimately, development. Constantly, the political authorities and the bureaucrats who assumed themselves as development experts asked the people to believe in "development" as a potential future achievement the success of which depends on the people's commitment and sacrifice in the present.

Although, many actors engage in development projects, which promise large national-scale results, it is questionable whether Sri Lanka has achieved the expected development and prosperity. More importantly, it is questionable whether the sixty-years of external support have actually improved the quality of life of the people of the country. This gives rise to significant questions: How do these external involvements in the name of development affect communities and individuals? Do these involvements have the honest intentions of encouraging people to meet their own aspirations? From their vantage points, how do people experience and respond to these external initiatives?

The issue(s)

In mid-2009, immediately after my undergraduate studies, I was employed by a project consultancy groupⁱ as a member of its survey team that worked for the well-known international NGO: World Vision. Since 1977, World Vision has been focusing on children, sustainability, participatory and area-based development. World Vision delivers its services to economically weak communities: It first selects a Divisional Secretariat Divisionⁱⁱ (henceforth DS division), and then identifies communities within it (villages, in rural areas) with a larger number of people under the poverty line. In these areas, World Vision carries out Area Development Programs (ADPs) the purpose of which is to develop and empower these selected communities. The normal life span of an ADP is 12 to 15 years; once the project is completed, World Vision moves onto another location to initiate a new ADP.

The survey team had two main tasks: First, to conduct awareness sessions about the 'good governance principles' for communities in two selected divisional secretariat areas: Mahakumbukkadawala and Nawagattegama. Both these are

located in rural areas, in close proximity. The second task was to conduct a feedback-survey measuring the satisfaction of the people in above villages concerning the services provided by World Vision.

During preliminary visits, some people in Mahakumbukkadawela told the survey team that they are unable to continue their lives without the assistance of World Vision. In Nawagattegama, however, the people did not need any special assistance to survive. I wondered whether development aid had made Mahakumbukkadawela people dependent, i.e., as opposed to the objective of empowering the community.

The key question is: does the discourse of development which reaches ground in terms of development projects empower communities or make them dependent. Particularly, how did people live before the NGO arrived? Is it a matter of time before Nawagattegama people will also become dependent? In this context, does development aid cause dependency and impoverishment? Then, what exactly makes people dependent? Are people manipulating dependency on their own? These questions inspired me to focus this study on “development” and its impact on the communities, particularly the World Vision projects in Mahakumbukkadawela and Nawagattegama.

The concept of development

The Concise Oxford English Dictionary defines development as “the process of developing or being developed” (2011: 392). As a verb, it is to ‘grow or cause to grow and become more mature, advanced, or elaborate’. In this sense, development is a maturing process and continuous growth. The foremost belief about development in the contemporary social sphere is its pivotal (perhaps the only) role to bring about prosperity and well-being for societies across the world.

At the end of the nineteenth century, there was a massive attraction of population to urban centres of countries and urbanization became widespread all over Europe. During the particular period, the term development combined with the urbanization process formed the term ‘urban development’ (Esteva, 1992). Although the notion of development was discussed in many disciplines, it still did not succeed in establishing the generalized (hegemonic) image that is associated with the world since World War II.

Since the Second World War, the entire non-Western world has pursued development at a national scale focused on the growth of national income. After it was introduced by Harry Truman, the President of the United State, in his inaugural address in 1949, development became a dominant term in the social discourseⁱⁱⁱ (Escobar 1994, Esteva 1992). Europe was rebuilt immediately after the World War II. USAID helped this transformation of many European cities from rubble to modern cities. The Truman Doctrine proclaimed science, technology and capital as the main ingredients of development, and that the American Dream of peace and abundance would be extended to all peoples on the planet (Escobar 1994: 3 - 4). In Truman’s speech, he mentioned poverty and lack of modern scientific knowledge as the main obstacles to the development of the people, communities and the nations in the world. Those states with such obstacles came to be known as the Third World. According to this doctrine, the undeveloped nations have to make sacrifices in order to achieve progress through enhancement of technology. The Truman doctrine, i.e., achieving rapid economic progress through substantial technological and industrial enhancement, defined the modern (post war) discourse of development. Development became a hard-hitting goal for the nations which did not have access to expensive technology.

When the concept of development emerged as progress or growth in the national economy, a well-known neoclassical economist, Walt Rostow (1960), brought the idea of stages of growth into the discourse. Rostow organizes economic transformation into five distinct stages to illustrate the economic evolution of history from an agrarian society to the modern era through the industrialization and the enhancement of technology. In Rostow’s terms, all nations will eventually develop, and the whole planet will be industrialized one day. Also, the national economies are independent of each other. If any nation is poor or still underdeveloped, the failure of one nation to develop does not affect the others.

This idea of economic independence was highly criticized by scholars who studied the causes of the ‘backwardness’ of Latin American economies. These critics were commonly identified as the Dependency School. Andre Gunder Frank (1971) came up with a radical insight into underdevelopment. He criticizes the idea that people of underdeveloped countries are responsible for the failures of their societies to develop. According to Frank, the so called “underdeveloped” countries were caused by the developed (core) nations, as part of their development process. The underdevelopment of peripheral states (economies) is a part of the same process of development of the core states. Furthermore, he argues that the peripheral nations are intentionally kept underdeveloped because the core states require cheap raw materials, labour and new markets for their products.

Bringing the whole world together, Immanuel Wallerstein (1979) proposes the 'world-systems perspective'; it views the core and peripheral nations as forming a single political economy which he calls the capitalist world-economy. He asserts the world economy emerged in the long 16th century in Europe (1450 – 1650). By the late 1850s, Wallerstein asserts that every country of the world had become a part of the world system. According to Frank, communities which are not a part of this system can be 'undeveloped', but not 'underdeveloped', for underdevelopment happens as part of the development process of the West. For Wallerstein, before their incorporation into the world-system, these societies are in the 'external arena.' After their incorporation, no state can completely give up Western influence (control and exploitation) at will to achieve its (independent) national development. Whatever development that takes place happens as part of the larger world-economy.

The 1990s began with many revolutionary changes in the political, economic, cultural, and geographical affairs of the world. The Union of Soviet Socialist Republic (USSR) collapsed in 1989, the Cold War between two opposing socioeconomic systems had come to a close, and the clash between the capitalist world and the communist world had come to an end.

Remarkably, some intellectuals argued that the (hegemonic) development discourse is almost dead, because its founding premises have been outdated by history (Sachs, 1992; Esteva, 1992; Escobar, 1995, 1997; Rahnama and Bawtree, 1997). They further claim that the USA may still feel that it is running ahead of other countries, but it is clear now that the race is leading towards an abyss (Ibid). In his edited volume *The Development Dictionary*, Wolfgang Sachs (1992) analyses the key concepts, the principles of the development discourse such as market, planning, poverty, progress, equality, etc. Each chapter indicates the transformation of those concepts from the early 1950s to the current day. Also, it clearly emphasizes how those key principles fail to meet their original objectives.

One of the key arguments made by post-development scholars is that development is a deliberately constructed discourse to maintain the so-called Third World as a development zone of the West. Elaborating this position, Arturo Escobar (1995) has encapsulated his ideas about development in *Encountering Development: The Making and Unmaking of the Third World*. Employing Michel Foucault's ideas of power, knowledge, and discourse, Escobar criticizes the larger edifice of Western ideas that supports development. He argues that the development discourse continues through dominant representations and prevailing institutional cultures that create the relationship between the West and the Third World. Escobar characterizes three main elements that make up the discourse of development: 1) the process of capital formation, 2) a series of cultural considerations, and 3) the creation of institutions such as the World Bank, IMF and USAID to facilitate the smooth operation of the First World. According to Escobar, the development discourse is not simply the collection of the above elements, but a system of relations established among them. For him, the idea is encapsulated in the belief that cultural, social, and political progresses are only achieved through material advancements. At the same time, development discourse is not a single or individual phenomenon but '... a system of relations ... [that] ... establishes a discursive practice' (1995:45). This particular 'discursive practice' of development comes through newly formed international organizations, government offices in distinct capitals, universities and research centres in developed countries and institutions in Third World countries. In reality, these 'experts' involved in 'abnormalizing' the normality of development would then be the same team coming up with the treatment and solutions to the problems and reforms created by them.

While development scholars continue their debates in regards to economic matters (unequal exchange, economic dependency, exploitation, control of the market, etc), Amartya Sen (1999) brings a new dimension to this debate. As they pursue economic growth, nations have neglected some important values in regard to lives and livelihoods. Often, in the mainstream society, development reflects on the growth of Gross National Product (GNP), the rise in per-capita income, or enhancement in industry and technology (Sen 1999; 3 - 11). Sen argues that states struggle to become wealthier in order to buy social goods such as education and health, but they lose sight of the development of their lives represented in 'freedom'.

For Sen, development goes beyond the accumulation of wealth and increasing the GNP, or per-capita income. The ultimate development is freedom; freedom of the people to live as long as they wish in the way they want. To achieve development the state should remove the deprivations or the major sources of 'unfreedom' that block the achievement of freedom, for example, poverty, poor economic opportunities, neglect of public facilities, and various social discriminations. At the same time, it should want to support aspirations through, for example, more economic opportunities, political liberties, social powers and enabling conditions of good health, basic education, and the encouragement and cultivation of initiatives (Sen 1999). This approach is now appropriated by global development agencies as "capacity building".

However, after sixty years of its official launching, the concept of development is still a dream in many non-western nations. One wonders whether any of those developing nations were able to achieve their targets. A common nature in all the developing nations is the younger generation was told that they were born in a developing country, same as their seniors. However, neither the seniors nor the young have experienced any so-called development.

In the early 1990's, scholars began to argue whether development is still valid. Sachs (1992) argues that both the US hegemony and the idea of development do not exist any longer. Further, Escobar (1995) stresses that the development discourse is the creator of underdevelopment in the world. Proposing a different perspective to read development, Sen (1999) portrays that development needs to be thought beyond monetary terms and economic growth. Furthermore, he argues development is only achieved through ensuring the economic, political, and social freedoms in a society. From these arguments, we can conclude that development is not simply a concept or a theory, but a whole system of ideas that has grown since the 1950s. In other words, this whole discussion indicates development as a discursively formed dominant representation. Also, this whole development discourse is embedded within capitalism and imperialism which it represents as natural.

However, if development is such a massive and powerful discourse, then no individual, community, or nation can simply avoid it. The crux of this discussion is, not to skip the discourse but to account for people as agents of change who respond to their subjectivity by becoming more than mere objects within the discourse. As discussed, postcolonial theory has played a significant role in this scenario. Postcolonial theory sheds light on a path to perceive human agency in the development discourse. It helps this research to go beyond the simple duality between the individuals and the development discourse. It opens up a fresh avenue to address the hybridization of local knowledge and the imported concept of development in practice.

The faith in development

As mentioned above, my first visit to Mahakumbukkadawala and Nawagattegama was as a member of a survey team of World Vision. World Vision had been in Mahakumbukkadawala for thirteen years, since 1997, and had two years to leave the area. Therefore, besides the community awareness we were supposed to get feedback from the community concerning the services the NGO provided since 1997. In Nawagattegama, however, World Vision had arrived a year ago and its development projects were at the initial stage. We were, therefore, not looking for much feedback. However, during our good governance awareness sessions, we encouraged the community to engage in the World Vision's development process.

My second visit to Mahakumbukkadawala and Nawagattegama was in late March 2013 to conduct fieldwork for this research project. The changes were substantial. There is no World Vision in Mahakumbukkadawala to assist the community and the people have survived themselves for 3 years after the NGO left. In Nawagattegama, however, people positively participate in World Vision programs. World Vision project meetings have become a part of their life. Apart from the place and the people, the past three years had also changed my vantage point of observation of both World Vision and people's agency. I no longer intend to impose mainstream development ideologies on people, but desire to experience the ways in which the communities encounter development.

Poverty - the great enemy

Immediately after my first meeting with the staff at World Vision's regional office in Anamaduwa town, I began walking a rutted street towards the central bus terminal. I was not alone: Prem, an Assistant Sector Coordinator^{iv} of World Vision also joined me to visit some villages in the Nawagattegama area. Moreover, he desired to give a preliminary overview about World Vision's development projects in different villages.

As we walked, we began to talk about the World Vision's contribution to the development and empowerment of the community in the Nawagattegama area. The he explained how he came in touch with World Vision and his experience of working with communities. He also emphasized how strongly the NGO is dedicated to their goal of empowering communities in Nawagattegama. During the conversation, he described the fundamental issue affecting the community:

Most of the people in these villages live in poverty. You can observe this everywhere in the village. Poverty is the main issue that we have to overcome. As our [World Vision's] key theme is the well-being of children^v, we help all poor families to overcome the poverty. We strongly believe that a child could have a better life, only if the child's family has a better income. Hence, it is our duty to help the poor people to overcome poverty. Of course, we do not get a big salary for our work. Actually, this is not a job, but good enough for living. It is a great commitment to the future generation.

He sounded very confident and certain about the tasks in which he is engaged as an employee of World Vision. He strongly emphasized poverty as the main source of all hardships of the community. Indeed, not only Prem, but also the other World Vision employees that I came across during this study were certain that poverty is the main issue of the people. They were all together in wanting to protect people from the adversities of poverty. For instance, during my conversation with the Area Manager of World Vision in Anamaduwa, I asked; 'What made you think that these people need your help?' He was very precise:

It is because they are so poor and most of them are uneducated. Thus, we are here to help them and to show them the right path to overcome poverty. Believe me, we are a team and we consider our duty to serve humanity. Since we are humans, we all have a great responsibility to help each other. ...make them stronger to achieve their targets and overcome all the miseries of their lives.

This response sounds like World Vision has a God-given responsibility and they are all united in stressing that World Vision is dedicated to ensuring a better future for children by eliminating poverty and empowering the community. As the majority of the rural population in Sri Lanka is discounted from mainstream development practices, World Vision employees believe it is essential to have their kind of alternative mechanisms to assist rural communities. They all believe that they are permitted and ethical to get involved in people's life in the name of development, empowerment, well-being of life, or simply the improvement of the standard of life.

As mentioned above, the criteria that World Vision employs to select DS divisions to provide its services are based on economic conditions. World Vision employs government census and statistical information to identify DS divisions where the majority of the people live below the poverty line. When it identifies a DS division to continue its development program, World Vision informs the Divisional Secretariat^{vi} of the area about its development program. If the divisional secretariat agrees to accept the program, it is expected to officially invite or request World Vision to carry out the development projects. In this sense, World Vision continues its development projects by invitation of the government. It also gives the impression that the project is carried out at the invitation of the state.

The categorization process

During these preliminary awareness sessions, World Vision groups the households in the village into four categories: (1) poorest of the poor – the poorest families in the village, (2) the poor – families which are not the poorest, but still facing substantial economic hardships, (3) moderate – most of the lower middle class families in the village belong to this category, and (4) well off – families with wealth and material possessions, assessed through the employment of the Participatory Wealth Ranking (PWR) method .

When I first exposed to these categories, I tried to apply this categorization process on myself. I was curious about how people feel and respond when they become conscious that they are poor. I also wondered how people accept these categories and their impacts over the community.

Gunarathne, a farmer and former Chairman of the World Vision's Village Development Committee (VDC)^{vii} in one village in the Nawagattegama area resonated the larger development discourse:

Based on its studies World Vision has identified the poor families in this village. According to World Vision, my family is in the poor category and I realized how poor we are. Also, we know that we need some [external] support to achieve a better life. World Vision is doing a great service in this area. It helps people to overcome poverty.

Due to World Vision's categorization, he was made to believe that his family belongs to the 'poor' category in the village. In fact, he was not the only person I came across who had identified himself as poor, but several other villagers believe that they are poor and need external support to survive.

World Vision's development process, when considered from a post-development standpoint, indicates that it constructs poverty instead of liberating the community. The development discourse adopted World Vision leads people to think of themselves as poor. During its categorization process, World Vision guides the villagers to label members of their community as poor based on their material wellbeing.

Conversely, the state also actively supports World Vision to continue this construction. It is because World Vision uses information from the government census to identify 'poor places'. Even, the government administrative agent officially invites World Vision to develop the area and empower the community. Although the project belongs to World Vision,

and it has the main role, it is impossible to identify World Vision as the only actor in this poverty determination and construction process; the state and the community of the area are also involved.

Dreams fall apart

Compared to Nawagattagama, the story of Mahakumbukkadawela is a sharp contrast. World Vision has left after its full term and the people in Mahakumbukkadawela area no longer have external support to ‘uplift’ their lives. During my fieldwork, they were in a transition period in their lives. I wondered how people experienced development and empowerment after World Vision had left. Some of the people I came across were very much oppressed and they were very critical about World Vision’s development process. I wondered why they were unable to achieve their goals (set by World Vision) during the last fifteen years.

Similar to Nawagattagama, World Vision had also formed a VDC for each village in Mahakumbukkadawela DS Division. With the collaboration of these VDCs, World Vision conducted many development projects in the particular area. Before it moved out of Mahakumbukkadawela after the specified fifteen-year term, following its modes of operations, World Vision opted to establish a mechanism to continue its development process into the future. In 2004, it formed an organization, ‘Green Vision’^{viii} as a body that supports World Vision’s development process. Then, World Vision began to withdraw in phases, transferring its responsibilities to Green Vision.

At the beginning, Green Vision did not have its own capital; World Vision provided the initial capital for investment purposes. With World Vision’s funds Green Vision started cashew nut and wood apple processing factories. As these plants were native to the Mahakumbukkadawela area, villagers sold their products to Green Vision. World Vision also arranged for one of the national grocery store chains to buy the Green Vision products. It also invested in an animal husbandry project. Under this project, members of the VDCs were given various animals such as goats, chickens, and cows; in return, the people had to take care of them for two years and return a specific number of animals, including the off springs, to Green Vision.

An education fund was another important Green Vision project. Through that fund, Green Vision provided scholarships to children in poor families so that they can continue their education even World Vision left them. Other Green Vision programs include those to make attitudinal changes in the community; youth development program is one such example. Being the backbone of all these projects, World Vision attempted to empower the community. Most people believe that it was the golden age of their villages. They all dreamt of a better future, a future without poverty and all the misfortunes of their current life.

The expired prosperity

In fact, World Vision projects gave people hope, a new life, and a new beginning. This new hope inspired the community and encouraged them to work hard to achieve their dreams. If someone would visit Mahakumbukkadawela in the mid-2000s, S/he would be fascinated with the progress made by the villagers, their courage, and unity. The community would have confidently said that they could achieve their dreams of development or eradicate poverty in the next ten years. They were hardly afraid of the withdrawal of World Vision’s assistance.

Unfortunately, the reality that I observed in Mahakumbukkadawela is extremely different from what these people originally thought and hoped for. When I asked villagers to talk about the World Vision’s development program, during my fieldwork, most of them were hesitant: One said, “oh, it was many years ago. What is point of talking about history?” Many others repeated this sentiment. According to another person; “it’s gone, it will never come back”. However, according to Wijaya - a former Chairman of World Vision’s VDC in Kandayaya for the first ten years - since World Vision moved out of Mahakumbukkadawela in 2009, his village has been like a ‘tire without air’. He explained some of the root causes of the collapse of the village community: “During the last few years people became very selfish. Eventually, we lost our unity and the community was splintered into different groups.”

In that sense, even though these villagers were trained to be leaders and they had participated in several workshops about the ‘importance of teamwork’, what they have developed through this process was not development, but individuality and a spirit of competition against one another. In addition to the community itself, some World Vision officials and employees were also responsible for the breakup of the community.

Some officials who joined the project in the last five years had created their own favorites, both individuals and groups, within the community. Some of those actions had enhanced the gap between World Vision and the community, particularly in the last few years. On the one hand, the people have eventually lost confidence in the World Vision’s

development process; on the other hand, the issues had destroyed the social harmony in the village. Daya is one of the founding social mobilizers of World Vision in Miyaellawa village in Mahakumbukkadawala DS Division. She mentioned:

Even several years after the departure of World Vision, people are still fighting and complain against each other. Now most of them have forgotten about World Vision, but they continue their old resentments and suspect each other.

Right at the beginning of the project, people were informed that World Vision would not stay with them forever. Through establishing VDCs and, later, a similar supporting body: Green Vision, World Vision expected to continue its own development process. Simultaneously, it assumed that the community would be able to manage their organizations without World Vision. Actually, the key objective of the World Vision development program was building self-confidence of the community so that it will overcome the poverty and achieve their aspirations. Instead of establishing a short-term development program, World Vision approached the community with a long, fifteen-year program and expected the process and the momentum to continue further. Although, they were organized to face their challenges, people lost their confidence immediately after the withdrawal of World Vision. Jayanath, a founding member and an employee of Green Vision, explained the situation:

After World Vision left us, it was very hard to find members to continue the VDCs. They [the villagers] assumed that they cannot achieve anything without the assistance of World Vision. The community participation dropped down to zero in many village development committees.

According to Jayanath, only a few VDCs are still functioning in the following villages: Dangahawela, Garayakgama, Kivula Number 1, Andigama, Baranankattuwa, and Western Galkuliya. In Dangahawela, Daya continues their Committee with a few members. She makes a great effort to find new members and encourages villagers to become members of the committee. Her committee has begun to issue small loans to its members. Through this kind of strategy, she hopes to incorporate people for the development of the village. Here the key seems to be her leadership. However, the destiny of the “people’s company,” Green Vision, is miserable. The company was established through a bottom-up process. The representatives of the village made all the decisions. It had a strong connection with the community at the grassroots level. In this sense, Green Vision is an emblem of bottom-up development. In reality, Green Vision was unable to protect any of these ‘unique characteristics’. As mentioned above, there was a position of a manager apart from the board of directors. Since, most of the directors did not have enough experience to manage a company; the position of manager was established as an independent position to support those directors to make decisions. The manager became stronger and more powerful than the board of directors and eased into the position of Managing Director of Green Vision. In Jayanath’s words:

Managing Director and the board of directors became puppets ‘in manager’s hand’. In practice, the manager’s role changed from being an assistant to the committee to its controller. At the end of the day, manager controlled everybody and there was nobody to control the manager.

Apart from these, most of the members of the Board wanted to earn credit for the achievements of Green Vision. They increasingly focused their attention on building their personal images, instead of working as a team. When Green Vision moved away from its original objective of empowerment of the community, World Vision refused to support it. According to Jayanath, there was ‘a tug of war’ between the Green Vision management and World Vision. As a result, Green Vision lost its reputation among the community. Immediately after, World Vision left the Mahakumbukkadawala area, and Green Vision became a powerless organization. Eventually, Green Vision has become almost completely hopeless. It still has Rs. 3 million in its education fund; it uses the interest of that money to continue the scholars program.

In sum, the beginning of the World Vision development program in Mahakumbukkadawala was highly successful. It gave hope to the community about its development. Although World Vision had hoped to continue the development process after its departure, this vision could not continue in the absence of World Vision. Hence, in the absence of World Vision, all its assumptions about development became fallacious. Through the withdrawal of World Vision, the entire dream of development has become distorted. This is well summed up in an idea about development that Wijaya shared with me before I left his house:

Sir, when the government or any other organizations give aid, people become addicted to that. This country will never develop with aid. If you want to develop this country, it should stop all foreign aid. Then people will start by themselves.

Conclusion

During the whole process, World Vision has given its priority to two main groups in the society: the poor and the children. If we consider common territories between the above groups, both are extremely vulnerable to discrimination by the mainstream society. Most of the time they are voiceless beings in the development discourse. In mainstream development practices, they are given very limited and controlled room to represent themselves.

Since the late 1940s, World Vision and several other development agencies have given their priority to address issues related to the poor and children around the world. Identifying this aspect is the uniqueness of the development approach of World Vision. It is important to recognize the NGOs reading about the poor and the children in Nawagattegama and Mahakumbukkadawala. During this study, I understood that World Vision encountered the people and children in the project areas as victims of poverty, not survivors. All the material, monetary, and technical assistance was aimed at improving the quality of lives of those victims who needed external help. World Vision's development process reflects the worrying assumption of the passivity of the people, which deprives them of their agency. During its process, World Vision gave hope to people, but it was blind to the fact that they are agents of (under)development.

Unless it takes account of the agency of the people, a development process can never empower the community. Therefore, the failure of the World Vision project is understandable, but people did not recognize it. That kind of development process can never make a real change in the society, but only a temporary excitation of the people. Therefore, World Vision can never expect the community to continue its development process.

Instead of empowering them, World Vision has transformed the community into "development beings". Those beings are knowledgeable about development and their inability to achieve it. They lack the self-esteem to overcome their deprivations. When the development agency left them, these development beings become destitute in an ambiguity of the memories of their pre-existing life (before the arrival of the development agency) and the knowledge they were given by the development agency. It causes these beings a great anxiety of their prevailing lives. People in Mahakumbukkadawala have already become development beings and as I believe the people in Nawagattegama are treading towards the same.

Notes

ⁱThis consultancy group was made up of two faculty members of the University of Moratuwa where I completed my undergraduate degree.

ⁱⁱThis is an administrative sub-unit in Sri Lanka.

ⁱⁱⁱAlthough development became more popular after President Truman's inaugural speech, the concept was already politicized under President Woodrow Wilson's period. At the same period, Vladimir Lenin as the first president of the USSR also mentioned the importance of 'progress' and 'economic development'.

^{iv}The Area Manager is the head of the regional office. There are Program Coordinators under the manager for different sectors of concern such as education, economic development, and child sponsorship. Each program coordinator has assistants for different sectors, titled - sector coordinators to maintain a better communication between the grassroots and town office.

^vWell-being of the children is one of the main concerns of World Vision. When it selects a divisional secretariat division, it is very concerned about the child population (age 16 and below) of the particular area. During the preliminary awareness sessions, World Vision highly encourages the community to involve their children in the child sponsorship program. World Vision makes a profile for every child who would like to get a sponsor. Then, it sends these profiles to donor countries such as the USA, Australia, Canada, and United Kingdom. Subsequently any individual, a group, or an organization that becomes interested in helping these children can select a child to sponsor. As sponsors, they have to make payments of \$30-\$40 for a child per month to World Vision. In the World Vision process, child does not directly receive this sponsorship, but it goes to a common pool. World Vision utilizes this money for the development of the whole community instead of the particular child.

^{vi}The local administrative officer of the particular divisional secretariat division.

^{vii}Every village has a Village Development Committee to carry out the development projects at village level to incorporated the villagers in the development of the village. Also, committees function as the community banks in the villages and committee members are eligible to received short-term loans with a reasonable interest rate. The interest from those loans was one of the main income sources of village development committee. Committee uses this money for the development of the village.

^{viii}Green Vision was managed by a Managing Director and a board of directors. Since, there are twenty-five village development committees in Mahakumbukkadawala divisional secretariat area, three members from each committee were appointed as the members of the main council of the company. Nine out of seventy five members of the main council were elected as the board of directors of the company. The director board appoints one of them as the Managing Director.

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