**ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY**

# PROPOSED CHECKLIST FOR BUILDING LIFE CYCLE COST ANALYSIS IN UGANDA

**M.Sc. THESIS**

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**Department of Architecture**

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**Thesis Advisor: Prof. Dr. Attila DİKBAŞ.**

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**İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ**

# UGANDA'DA BİNA YAŞAM DÖNGÜSÜ MALİYET ANALİZİ İÇİN ÖNERİLEN KONTROL LİSTESİ

**YÜKSEK LİSANS TEZİ**

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**HAZIRAN 2013**

**Julius HAKIZIMANA**, a **M.Sc.** student of ITU **Institute of / Graduate School of Science Engineering and Technology** student ID **502111417**, successfully defended the **thesis** entitled "**PROPOSED CHECKLIST FOR BUILDING LIFE CYCLE COST ANALYSIS IN UGANDA**", which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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***To my my family for all the support and confidence they have had in me throughout my education and life. In a special way to my younger brother who had an accident less than a month after I left my country to pursue my master degree. He is still recovering and in a stable condition. You have all kept me going on this journey.***

***I love you so much.***

**FOREWORD**

In a special way, I would like to thank the all might God for the good health and fortunes He has continued to bless me with throughout my entire life.

A special gratitude goes to my supervisor Prof. Dr. Attila DİKBAŞ who has guided me throughout and allowed me to use his office as a study environment.

I would also like to thank my friends, both in Turkey and Uganda that kept inspiring and encouraging me throughout my masters program.

Not forgetting, all my lecturers that have endlessly given me knowledge and opened my mind to new ways and greater horizons. Thank you.

This work has been mainly inspired by my desire to contribute to the development of my country Uganda. I hope this will be the begining of such contributions.

May our good Lord bless you all, In the name of the Father and of the Son and of the Holy.

June 2013 Julius HAKIZIMANA

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**ABBREVIATIONS**

| | |
|---|---|
| **AAMCoG** | **:** Australian Asset Management Collaborative Group |
| **AIA** | **:** American Institute of Architects |
| **BCIS** | **:** Building Cost Information Service |
| **BoQ** | **:** Bills of Quantities |
| **CPDs** | **:** Continuous Professional Development seminars |
| **CRC** | **:** Cooperative Research Centre |
| **EAC** | **:** Equivalent Annual Cost |
| **GDP** | **:** Gross Domestic Product |
| **LCA** | **:** Life Cycle Assessment |
| **LCC** | **:** Life Cycle Cost |
| **LCCA** | **:** Life Cycle Cost Analysis |
| **LCM** | **:** Life Cycle Management |
| **MR&R** | **:** Maintenance, Repair and Renewal |
| **NIST** | **:** National Institute of Standards and Technology |
| **NPV** | **:** Net Present Value |
| **PFI** | **:** Private Finance Initiative |
| **PPP** | **:** Public Private Partnerships |
| **PV** | **:** Present Value |
| **RICS** | **:** Royal Institute of Chartered Surveyors |
| **SETAC** | **:** Society of Environmental Toxicology and Chemistry |
| **VFM** | **:** Value For Money |
| **WLA** | **:** Whole Life Appraisal |
| **WLC** | **:** Whole Life Costing |

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## PROPOSED CHECKLIST FOR BUILDING LIFE CYCLE COST ANALYSIS IN UGANDA

## SUMMARY

The purpose of this study was to propose a checklist for carrying out Building Life Cycle Cost Analysis (LCCA) in Uganda. Literature reviews of some of previous research on Life Cycle Cost Analysis and Management was done into order to find out what information and how it is being used by building professionals today to carry out LCCA. Difficulties and limitations of the application of LCCA from the literature were also mentioned. Moreover, the tools, considerations and assumptions made before and during an LCCA application were highlighted.

Focus was then drawn to the situation in Uganda. Uganda is a developing country located in Africa in the East African region. Its local construction industry is still under developed and still faces a lot of challenges. In fact, the local construction industry continues to witness a loss of large construction projects to the international construction consultants and contractors rather than to gradually build on its local capacity. Uganda's local construction industry faces a number of problems such as lack of proper construction management and technical capacity, lack of easy access to credit facilities, lack of proper application of advanced construction techniques and information technology, to mention but a few. However, for this research a brief about the topic of LCCA and questionnaire forms were distributed among some professionals and organisations practising in Uganda.

The brief was meant to give the responder an overview of Life Cycle Cost Analysis and Management and also briefly elaborate on the methodology and purpose of the study. The questionnaires distributed were used to find out first, whether LCCA is performed in Uganda or not. Then information about how LCCA is done and what sources of information are available for that in Uganda was collected. Information concerning difficulties, limitations and what they way forward should be in relation to the application of Life Cycle Cost Analysis for Uganda in particular was obtained. A comparison was then made with what is being done in the developed world and with what exists in the available literature on Life Cycle Cost analysis. All this was done with the sole purpose of coming up with a proposed checklist of how LCC analysis can be done in Uganda.

From the questionnaire responses, it was discovered that most of the professionals interviewed knew about the concept of Life Cycle Cost Analysis and Management. However, majority of them did not actually practise this application at their places of work. Those who did only did it partially. They rather applied other construction economic evaluation techniques also used at a global scale. Some of the reasons given for the lack of application of Life Cycle Cost Analysis were; client & professionals ignorance on the concept of LCCA, the need for a lot of time and resources which they cannot afford, lack of enough information and data, limited

access to available resources and data, and unreliability of available data and information among other reasons.

However, a number of the sources of such information and data were similar to what was observed in the literature reviews. But, Uganda still lacks certain important sources such as lack of a data bank where different professionals offer information about their projects. Such a data bank would then be used as a reliable source of data and information for Life Cycle Cost Analysis. Uganda also does not have any known guide or framework to assist a Life Cycle Cost Analysis. Neither is there anybody, organ or association that advocates for the application of Life Cycle Cost Analysis.

Despite the difficulties and challenges Life Cycle Cost Analysis application faces in Uganda, a proposed checklist was made. It included steps and procedures for Life Cycle Cost Analysis in Uganda. The different stages involved were extensively elaborated upon. The critical variables in any LCCA were expounded upon to help one succeed with the analysis in Uganda. These variables included; discount rate, analysis/ study period, methods of Life Cycle Costing (LCC) and the cost categories. Two tables were also proposed to assist in having an organised analysis, display of the results and for easy comparison and decision making.

Recommendations for how Life Cycle Cost Analysis practise can be encouraged in Uganda were made and how the difficulties and challenges can be overcome. Furthermore, recommendations for future research areas to improve on the Life Cycle Cost Analysis practise were made. Not only were they focused on Uganda alone but the world in general.

## UGANDA'DA BİNA YAŞAM DÖNGÜSÜ MALİYET ANALİZİ İÇİN ÖNERİLEN KONTROL LİSTESİ

## ÖZET

Bu çalışmada Uganda'da uygulanmak üzere Yapı Yaşam Döngüsü Maliyet Analizi (LCCA) için Kontrol Listesi oluşturmak hedefleniyor. Bu çalışmanın metodolojisi, uzun bir araştırma ve fikir alışverişi sonucu oluşturulmuştur. Çalışma temel olarak dört aşamada gerçekleştirildi. Bu aşamalar: 1-) Literatür araştırması; 2-) Antet tasarımı ve araştırma istatistikleri; 3-) Analiz ve tartışma; 4-) Uganda'da Yapı Yaşam Döngüsü Maliyet Analizi geliştirmek için bir takım araç önerileri ve intikat şeklinde özetlene bilinir.

Dünyanın değişik yerlerinde hazırlanan ve kullanılan LCCA yöntemi ile ilgili literatürdeki çalışmalar, kullanılan analiz yöntemleri ve yorumları bu çalışma kapsamında gözden geçirildi. Yapılan detaylı literatür taramasının amacı, bugünün profesyonellerinin LCCA'yı nasıl uyguladıklarını anlamak içindi. Bu amaçla LCCA yöntemi için mevcut olan kısıtlamalar, zorluklar ve şartlar incelenmiştir. LCCA yönteminin uygulanmasından önce ve uygulanması sırasında dikkate alınması gereken hususlar, varsayımlar ve kullanılan araçlar özellikle irdelenmiştir.

Elde edilen bilgiler ışığında Uganda'daki durum incelenmiştir. Uganda, Doğu Afrika'da yer alan gelişmekte olan bir ülkedir. Uganda'daki yerel inşaat sektörü henüz yeni yeni olgunlaşmaya başlamıştır. Yerel inşaat şirketlerinin karşılaştıkları zorluklar rekabet edebilirlerinin düşmesine neden olmakta ve ülkedeki büyük inşaat projesi ihaleleri yabancı müteahhitler tarafından üstlenilmektedir. Bu nedenden ötürü, Uganda inşaat sektörü için yerel inşaat kapasitesinin geliştirilmesi önem arz etmektedir. Uganda yerel inşaat sektörünün temel sorunları; teknik kısıtlamalar, ekonomik olmayan teknolojik ürünler, yüksek faiz oranları, ileri teknolojilerin doğru kullanılamaması ve inşaat yönetiminde bilişimden faydalanılamaması şeklinde özetlenebilir. Bu sorunların yapı sektörüne yansıması direkt olarak yapı maliyeti üzerine olmaktadır. Bu çalışma kapsamında, yapılan incelemeler sonunda Uganda yerel inşaat sektörü tarafından kullanılan LCCA yöntemi hakkında bilgi edinebilmek amacı ile bir anket hazırlanmıştır. Hazırlanan anketin, Uganda yerel inşaat sektöründe hizmet veren birkaç kurum ve profesyoneller tarafından değerlendirilmesi sağlanmıştır.

Anketi değerlendirenlere, LCCA hakkında geniş bilgi verilmiştir. Bu çalışmanın amacı ve LCCA yöntemi kullanılmasının önemi anlatılmıştır. Hazırlanan anket iki bölümden oluşmaktadır. Birinci bölüm, ankete katılanlar hakkında genel bilgi ve geçmişleri hakkında bilgi toplamak amacıyla hazırlanan sorulardan oluşmaktadır. İkinci bölüm ise 'Yapı Yaşam Döngüsü Maliyet' ile ilgili soruları içermektedir. Ankette, Uganda'da yerel inşaat sektöründe LCCA'nın uygulanıp uygulanmadığı sorulmuştur. LCCA uygulayan firmaların ellerinde ne kadar bilgi olduğu ve bu bilgiyi nasıl kullanıldıkları ayrıca incelenmiştir. LCCA uygulamaları için Uganda'da ne kadar bilginin temin edilebilir olduğu sorgulanmıştır. Bunun yanı sıra, LCCA uygulamasıyla ilgili yaşanan zorluklar, kısıtlamalar ve önerilen çözümler de

sorulmuştur. Bu anket aracılığı ile elde edilen bilgiler, dünyadaki diğer gelişmiş LCCA uygulamaları kullananlar ile karşılaştırılarak ilgili notlar ve faklı uygulamalar ortaya çıkarılmıştır. Bu çalışmanın temel amacı Uganda yerel inşaat sektöründe uygulanmak üzere LCCA için Kontrol Listesi oluşturmaktır.

Çalışmada bu amaçla örnek alma sistemi kullanıldı. Araştırmacı, özellikle ankete katılacakları seçerek, araştırmaya faydalı olacak gerekli bilgileri toplamaya hedeflemiştir. Gelişmiş ülkeler dâhil olmak üzere dünyadaki birçok ülkedeki inşaat sektörünün, 'Yapı Yaşam Döngüsü Maliyet Analizi' uygulamaları açısından daha çok yol alması gereklidir. Buna göre yeni yeni gelişmekte olan Uganda yerel inşaat sektörü aktörlerinin ankete katılmaları ve seçimleri son derece önemlidir. Uganda örneği LCCA açısından bu konuda istisna olmayıp, özellikle inşaat sektörü bakımından gelişmesi ve değişmesi gereken birçok nokta bulunmaktadır. Bu çalışmada toplanan veriler profesyonel kurumların (Uganda Mimarlar Odası, Uganda Haritacılar Birliği vb. üyeleri) kayıtlı ve lisanslı üyeleri seçilerek toplanmıştır. Anketin uygulandığı kişiler seçilirken: 1-) Çalışma alanları (hem akademik hem piyasada faaliyet gösteren profesyoneller); 2- ) Devlet kurumlarında çalışanlar; 3- ) Tecrübeli ve bilinen çalışanlar (tanınmış şirketlerde çalışanlar tecrübeli personel); 4-) Meslektaşları tarafında önerilen kişiler (farklı önemli kişiler); 5-) Akademik seviyeler (birden fazla lisans derecesine sahip olanlar, özel konularda çalışma yapmış olanlar ve çeşitli ülkelerde eğitim görmüş ve çalışmış olan) bu tür özelliklere dikkat edilerek seçim yapılmıştır. Bu çeşitlilik araştırma için oldukça faydalı olmuştur.

Anket çalışması uygulanırken, katılımcı olan yapı profesyonelleri ve kurumların birçoğunun LCCA konsepti ile ilgili bilgisi olduğu ortaya çıkmıştır. Fakat elde edilen bulgular ışığında çoğunlukla inşaat sektöründe, LCCA' nın kısmen veya hiç uygulanmamakta olduğu kanısına varılmıştır. LCCA yerine dünya çapında kullanılan diğer inşaat ekonomi analiz yöntemleri uygulamaları tercih edildiği görülmüştür. LCCA'nın uygulanmamasının sebepleri arasında; müşterilerin ve diğer profesyonellerin LCCA hakkında yeterli bilgilerinin olmaması, LCCA için gerekli olan zaman ve kaynak ihtiyacına sahip olmamaları, yetersiz bilgi, veri tabanı ve yeni bilgiye ulaşmanın getirdiği zorluklar sayılabilir.

Anketin ortaya çıkardığı sonuçlar ile literatürde yer alan çalışmalar arasında benzerlikler olduğu görülmüştür. Uganda'da bir veri bankası olmaması sağlıklı veri kaynaklarının eksik olması, profesyoneller için projelerinde kullanabilecekleri bilgi yetersizliğine neden olmaktadır. Bir veri bankası olması durumunda, LCCA çalışmaları için güvenli bilgi kaynağı temin edilerek kullanılabilir. Ayrıca, Uganda'da resmi olarak LCCA ile ilgilenen kurum veya sorumlu olmadığı tespit edilmiştir. Bunun yanı sıra, Uganda'nın yapı sektörüne yönelik bir LCCA yönetmenlik veya altyapı da bulunmamaktadır.

Bu çalışmada, Uganda'daki LCCA uygulaması kısıtları ve zorlukları için çeşitli öneriler elde edilmiştir. Bu önerilerin derlenmesi sonucunda, LCCA uygulamasında kullanılabilecek bir kontrol listesi hazırlanmıştır. LCCA'nın farklı aşamalarını anlatan bir geniş bir metin de yine kontrol listesi kapsamında hazırlanmıştır. Başarılı bir LCCA uygulaması elde etmek için kritik değişkenler belirlenerek bunların sıralaması yapılmıştır. Bu değişkenlere örnek vermek gerekirse; indirim oranları, analiz/çalışma zamanları, Yaşam Döngüsü Maliyetlendirme metotları ve maliyet sınıfları bunlar değişkenler arasında yer almaktadır. Düzenli bir analiz yapılabilmesi için iki ayrı tablo hazırlandı. Bunlar sonuçları göstermek, karşılaştırma ve karar verme sürecini kolaylaştırmak için iki ayrı şekilde oluşturulmuştur.

Uganda'da LCCA uygulamasını teşvik etmek için bazı öneriler geliştirilmiştir. LCCA uygulamaları önünde yer alan kısıtlamaları ve zorlukları en etkili şekilde aşmak için

çeşitli alternatifler sunulmuştur. Bu önerilerden bazıları: seminer ve eğitimlerle bilgilendirme toplantıları yaparak Yaşam Yörünge Maliyetin önemini vurgulamak; yüksek eğitim kurumlarda LCCA konseptinin tanıtımını yapmak; tanıtım programlarını çalışan profesyonellere kadar uzatmak; aynı şekilde profesyonellerin müşterilerine LCCA konseptini anlatmalarını sağlamak; profesyonellerin kişisel olarak veya kurumsal olarak LCCA verileri toplamalarını ve bu hizmetleri yatırımcılara kadar verilmesi sağlamak; veri bankaların uyumlu hale getirilmeleri ve profesyonel üyelerin bu veri bankalarına kolayca ulaşabilmelerinin yolunu açmak; devlet veya kamu (Uganda) desteği ve Doğu Afrika'dan bölgesel destek alarak araştırma yapma olanağını sağlamak; yayınlama sistemlerin oluşturulması; teknoloji konfigürasyonların geliştirilmesi ve son olarak da İnşaat sektöründen sorumlu devlet kurumlarının LCCA uygulamasının inşaat izni alınırken zorunlu hale getirmeleri gibi çok çeşitli öneriler bu çalışma kapsamında sunulmuştur.

Tüm bunlara ilaveten, gelecekte LCCA uygulamalarını kolaylaştırmak için yapılacak araştırmalara uygun alanlar da çalışma kapsamında önerilmiştir. Bu öneriler sadece Uganda için değil, bütün dünyanın faydalanabileceği şekildedir. Bu araştırma dâhilinde yapılan öneriler; doğru yönetimler ile elde edilecek ektili LCCA oluşturabilmek için daha fazla araştırma yapılmasını gerektiği; sürdürülebilir ve yapı çevresindeki ilişkileri, analizleri ve LCCA bağlantılarını kapsayan çalışmalara öncelik verilmesi gerektiği şeklindedir. Bu iki özelliğin nasıl birlikte uygulanacağı da ayrıca araştırılmıştır. Anılan çalışmada, LCCA'nın diğer yapı ekonomileriyle nasıl bağdaştırılabilir olduğu ve bir ortak çalışmasının nasıl yapılacağı da araştırılan diğer konular arasında yer almaktadır. Çalışma kapsamında daha başarılı LCCA uygulamalarını yayınlamak için daha özel araştırmalar ve doğru LCCA veri bankasının oluşturulmasının faydaları üzerinde durulmuştur. Son olarak, yapılan çalışmada yapı malzemelerinin, elemanlarının ve sistemlerinin ömürleri araştırılmıştır.

# 1. INTRODUCTION

## 1.1 Background of Study

The construction industry is one of the most booming industries in the world for both the developed and developing nations. This dissertation will focus on the construction industry in Uganda. Refer to appendix C for the location of Uganda on the African continent. Uganda is a developing country in East Africa and has over the past decade experienced a boom in the construction industry. World over but Afrıca in particular, many people are migrating from rural areas to urban areas in search of better opportunities and living conditions. Therefore there has been an increased demand for infrastructure to cater for this ever growing population. As more construction projects are being commissioned worldwide, it is the responsibility of the owners and building professionals to ensure that they meet the desire goals, purposes and building standards. Not only aesthetically, but also use and comfort, environmental and importantly economic goals. Project Economic Evaluations are expected to be carried out not only to determine whether a project is feasible or not but also to enable the investor make a choice between two or more possible project options. This will bring into place the need for proper building and infrastructure Life Cycle Cost Analysis and Management.

Generally, a lot of focus has been place on the need to minimized construction costs of a building forgetting about the impact of other building related costs and the decisions made during the various project stages on the general building life cycle cost. Other costs besides construction costs may include; initial land acquisition costs, maintenance and repairs, renovations, design costs to mention but a few. Decisions to be made may include what project alternative to take on, what kind of building systems, materials, building shape, site location and many more that could significantly affect the long term cost of the building. It is important to note that minimising the cost of construction does not automatically lead to a reduction on the total Life Cycle Cost (LCC). On the contrary, a higher construction cost could lead to

a reduced LCC provided other long term costs are put into consideration, hence the need for proper Life Cycle Cost Analysis and Management.

Today, we see more and more focus is being turned to building Life Cycle Cost management rather than just single phases of buildings' lives. This means that a lot of data, records and information about a building, its materials and systems have to be gathered for one to make a proper LCC Analysis. A number of challenges have been documented and research done in this area that will be explored in the literature review.

For Uganda just like most other countries, the construction industry is an important contributor to its' GDP (Gross Domestic Product) and a catalyst to other sectors of the economy. The construction industry is also a means through which many citizens improve their livelihoods. Past researchers have stated that it is not an easy and straight forward task to deal with a building's Life Cycle Costs because of the difficulties and limitations (that will be mentioned in the next chapters). Uganda is a developing country and therefore is not as advanced in construction technics as those in Europe or America. In fact, its local construction industry is still under developed and still faces a lot of challenges. Today, the local construction industry continues to witness a loss of large construction projects to the international construction consultants and contractors rather than to gradually build on its local capacity. Uganda's local construction industry faces a number of problems such as lack of proper construction management and technical capacity, lack of easy access to credit facilities, lack of proper application of advanced construction techniques and information technology, to mention but a few.

Therefore obtaining accurate and complete data to carry out a LCC Analysis may be very difficult. But using the data and methods available, a checklist has been proposed for how best one can carry out a Life Cycle Cost Analysis in Uganda.

## 1.2 Aim and Objectives

**Aim:**

To propose a checklist for Building Life Cycle Cost Analysis in Uganda.

**Objectives:**

a. To review current literature on Life Cycle Cost Analysis.
b. To find out what information is necessary and/ or used for Life Cycle cost analysis in the developed world.
c. To find out whether Life Cycle Cost analysis is practised in Uganda and what information and data is used and how it is done.
d. To compare the LCC Analysis practise in Uganda with the developed world and existing theoretical literatures.
e. To propose a Checklist for Life Cycle cost analysis in Uganda.

## 1.3 Research Methodology

### 1.3.1 Stage 1: Literature review

Various readings were done from various relevant sources which covered textbooks, institutional and statutory publications, periodicals and academic journals, seminar and conference papers. This was done with the aim of theoretically understanding what Life Cycle Cost Management and Analysis in particular means, what data and information is required to perform a proper analysis and their sources, how this data and information is used, what is currently being done, what has been researched about and also to know the problems encountered during this process of LCC Analysis and what writers say the future holds for Life Cycle Cost Analysis and Management.

### 1.3.2 Stage 2: Questionnaire and information gathering

Information was gathered from building professionals and/ or practisioners in Uganda. The questionnaire form was divided into 2 sections. The first section gathered general information about the building professionals filling the form. Questions about his/ her professional background, place of work, experience, nature of projects usually done and level of education of clientele were asked.

The second section included more specific questions with the aim of finding out what is actually done and whether Life Cycle Cost Analysis is performed in Uganda. And what can kind of data and information is available and can be used for Life Cycle Cost Analysis in Uganda. What difficulties are experienced by these professionals

and what they think can be done to better improve and promote the practise of Life Cycle Cost Analysis in Uganda.

### 1.3.3 Stage 3: Analysis and discussion of findings

A brief comparison of the information gathered from professionals in Uganda was made with existing literatures, theoretical practises and researches that have been made of practises in the developed world. Differences and similarities were pointed out. This was done with the aim of visualising where Uganda lies as compared to the developed world in terms of LCC Analysis practises.

### 1.3.4 Stage 4: Proposed checklist for building life cycle cost analysis in Uganda

After comparisons and discussions of the findings from the questionnaires and literature reviews, a checklist for carrying out Life Cycle Cost Analysis in Uganda was proposed.

### 1.3.5 Stage 5: Conclusion

A conclusion was made that will include the problems and limitations, reasons why LCCA should be taken up, recommendation to be done in Uganda and proposals for further research.

### 1.4 Dissertation Outline

Stage 1: Literature Review

Chapter 1: Introduction

Chapter 2: Literature Review of Life Cycle Cost Analysis and Management

Stage 2: Questionnaire and Information gathering

Chapter 3: Questionnaire Design and Survey Statistic

Stage 3: Analysis and Discussion of findings

Chapter 4: Analysis and Discussion of Questionnaire Data

Stage 4: Proposed Tools for Life Cycle Cost Analysis in Uganda

Chapter 5: Proposed Tools for Life Cycle Cost Analysis

Stage 5: Conclusion

Chapter 6: Conclusion

# 2 LITERATURE REVIEW

## 2.1 Definitions and Terminology

There are a number of different literatures about Life Cycle Cost and it has over the years been defined in many different ways by different authors. But all having the same core principle and meaning which is; it is an all cost including economic evaluation technic. The National Institute of Standards and Technology (NIST) Handbook 135, 1995 edition defines Life Cycle Cost (LCC) as "the total discounted dollar cost of owning, operating, maintaining and disposing of a building or a building system" over a period of time (Life Cycle Cost Analysis Handbook – 1st edition 1999). Life Cycle Cost is the total ownership of machinery and equipment, including its cost of acquisition, operation, maintenance, conversion and/ or decommissioning (SAE 1999). Another author states, LCC is defined as "the total cost, in present value or annual value, that includes the initial costs, maintenance, repair and renewal (MR&R) costs over the service life or a specified life cycle" (Saidur Rahman and Dana J. Vanier, 2004). Saidur and Dana further define Life Cycle Cost Analysis (LCCA) as the process of evaluating the total economic cost of an asset by analysing initial costs and discounted future expenditures, such as maintenance, repair and renewal (MR&R) costs, and user and social costs over service life of the asset.

However, today different terms have been used in various literatures which could be confusing to the reader. They include; "cost in use", "Life cycle cost (LCC)", "Whole life costing (WLC)" and "whole life appraisal (WLA)". According to Flanagan and Jewll (2005), over years the terminology has changed from "cost in use" to "life cycle costing" and further to "whole life costing". BS ISO 15686 Part 5(2008) is an international standard for property life cycle costing that has been adopted by the UK and has been developed by industry and in consultation with 17 countries. It clarifies on the terminology of WLC and LCC in order to eliminate the confusion between these terminologies. Below is a figure the illustrates this;

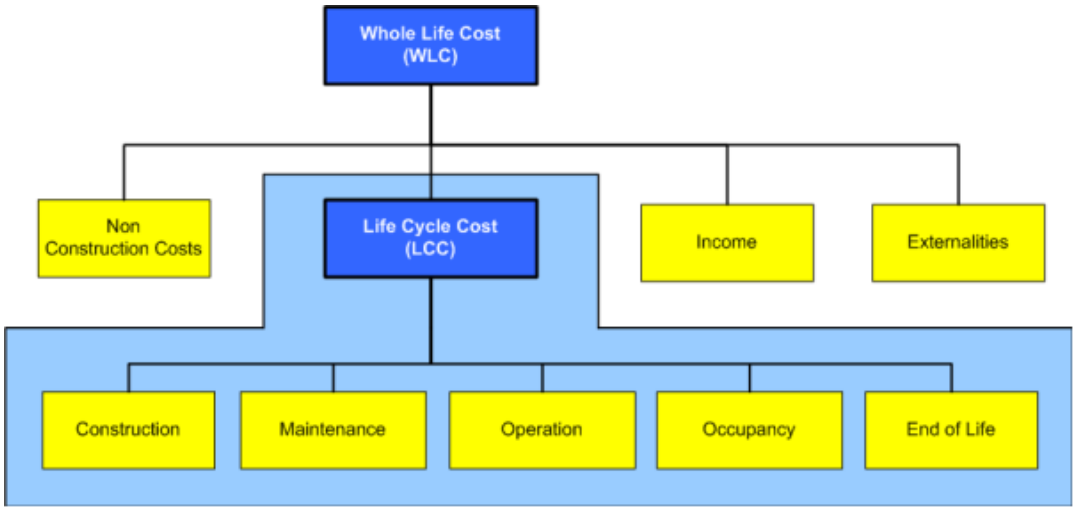


**Figure 2.1 :** Differenciation between terminology.

In BS ISO 15686 Part 5 et al (2008), it defines Life Cycle Costing as "is a methodology for the systematic economic evaluation of the life cycle costs over the period of analysis, as defined in the agreed scope." It then defines Whole Life Costing as, "is a methodology for the systematic economic consideration of all the whole life costs and benefits over the period of analysis, as defined in the agreed scope" According to this document, Life Cycle Costs include; construction, maintenance, operation, occupancy and end of life or destruction costs. Whereas Whole Life Costs include the Life Cycle Costs plus non construction cost, income plus externalities.

For consistency in this dissertation however, Life Cycle Costs and Whole Life Costs will be considered the same as defined above in the BS ISO 15686 Part 5(2008) and as illustrated in figure 2.1

Life Cycle Assessment (LCA) is another term that may somewhat be confused with Life Cycle Cost Analysis. LCA "is one such tool that can help companies to understand the environmental impacts associated with their products, processes, and activities." Susan Svoboda, (1995). According to AIA Guide to Building Life Cycle Assessment in Practice et al (2010), a differentiation between the two is "LCC provides decision support in selection of a building system or whole-building design based on its financial benefits, as opposed to LCA, in which a decision is based on the environmental benefits of a system or design." So LCA is more concerned with the impact the building will have on the environment. It deals closer with issues

pertaining to sustainability and 'green building' approach. While LCC on the other hand deals with the buildings cost issues throughout its life cycle.

Another important terminology is Life Cycle Management (LCM) which can be seen as a framework in which methods such as Life Cycle Assessment and Life Cycle Costing are used to support decisions leading to sustainable development. The SETAC (Society of Environmental Toxicology and Chemistry) Working Group has defined LCM as "a flexible integrated framework of concepts, techniques and procedures to address environmental, economic, technological and social aspects of products and organizations to achieve continuous environmental improvement from a Life Cycle perspective." Life Cycle Cost Management therefore is a framework within which different technics and methods are used to support decisions leading to or based on the financial benefits of a building and/or its impact on the environment.

## 2.2 Why Do Life Cycle Cost Analysis and its Benefits

Financial constraints on projects are becoming more and more thus the need to not only consider the upfront costs as a basis for making decisions on an investment or on which system to use but rather to consider its cost over a period of time (i.e. its life cycle). The facility's cost over a given period of time and a particular system's cost over the facilities life time brings about the need for Life Cycle Cost Analysis. LCCA is a decision making technic that does not only consider the initial and upfront costs but rather the cost over the life of the facility or the system considering all related costs, and includes construction, operation, maintenance and decommissioning.

Institutions, governments, organisation and other bodies perform LCC Analysis for their own special reasons and in unique and specialised ways. For example in State of Alaska the Department of Education and Early Development was charged with the responsibility of determining if a school capital project is in the best interest of the State of Alaska. They have created a Life Cycle Cost Analysis handbook that will help in demonstrating that a school district's project request is not only the best solution for the district themselves, but also for the State of Alaska.

**The need for planning and analysis;** "The best opportunities to achieve significant cost benefits occur during the early concept development and design phase of any

project. At this time, significant changes can be made for the least cost" P J Barret (2011. This is because during the latter stages of a project many costs are tied and it is difficult to change or allocate them elsewhere. According to P J Barret (2011), at this stage the following should be explored:

- *A range of alternative solutions*
- *The cost drivers for each alternative*
- *The time period for which the asset will be required*
- *The level and frequency of usage*
- *The maintenance and/ or operating arrangements and cost, and*
- *Quantification of future cash flows*.

Through LCCA, all the above can thoroughly be explored and analysed thus enabling proper planning and analysis for the future. And all these must be determined early in the assets Life Cycle

**The selection of the best option;** LCC Analysis is a tool primarily for selecting the best from different available alternatives available. P J Barret (2011) also states that through preparing a LCCA for each option it is possible to:

- *Calculate the Net Present Value (NPV) of each option*
- *Consider projected cash flows in the context of the funding available and*
- *Identify issues related to ultimate disposal of the asset.*

Decision makers can therefore find this information very useful and use it as part of the selection process together with other guidelines and constraints. This should enable them to select the best project alternative or building system/ component.

**To securing funding**; at any given time, there are competing demands for the available cash within any given organisation. LCCA provides a sound basis for cash flow requirements thus assists in securing funding and approval for a particular project. This is because LCC Analysis will enable stakeholders to view and be aware of the related current and future costs of a proposal through its life time on a periodical basis.

The International Infrastructure Management Manual (2006) and the Australian/ New Zealand standards guide on LCCA (AS/NZS 4536:1999) provide a

comprehensive list of applications in which LCCA is most commonly utilised. They include: “

i. *The evaluation options for the procurement of new assets such as design trade-offs, source selection and affordability studies.*
ii. *The on-going support of management decision making throughout the life of an asset (building/ system).*
iii. *The identification of asset attributes which significantly influence LCC, allowing their proper management. These are often referred to as ‘cost drivers’*
iv. *The benchmarking of assets actual cost performance.*
v. *The review of the procurement process for future design/ acquisition decisions.”*

LCC Analysis is an important tool in the design process for controlling the initial and future cost of building ownership. It can be applied at any level of the design process which makes it critical since this is an important stage where decisions with far reaching consequences are made.

It can also be used to evaluate existing building systems to determine whether it is time for maintenance, replacement, repair or renovation.

Different organisations, institutions and public bodies around the world have developed their own guides for performing Life Cycle Cost Analysis for various reasons and benefits specific to them.

## 2.3 Tools Used and Considerations

### 2.3.1 Stages considered

A proper LCCA is expected to be performed for all stages of the life of an asset/ facility. This includes acquisition, construction, operation/ occupancy and finally the decommissioning stage

According to P J Barret (2011), there are generally three stages at which Life Cycle Costing should be applied; when decisions for investment are being made i.e. the conceptual stage, when tenders for supply of building systems, equipment software etc are being assessed i.e. the acquisition stage and the in-service stage during

operations when decisions to replace, repair, improve or dispose an asset are being considered.

Conceptual stage: “The emphasis here should be on getting at least initial estimates for all the key components of life cycle cost organised consistently so as to ensure a fair comparison between alternatives” P J Barret (2001). This stage involves all initial decisions on what options to consider for investment.

Acquisition stage: This is where LCC is used to help select the most cost effective option. And this can form part of a tender process using a preliminary model of the asset and it’s environment, identifying possible acquisition costs and factors affecting other costs and considering means of minimizing such costs.

In-service stage: By knowing the actual operational cost of facilities helps improve their cost effectiveness and that of future acquisitions. Hence the importance of having someone especially responsible for recording and following up of all operational expenditures of a facility. Hence the availability of a comprehensive and readily useable data base of life cycle costs enables decisions on changes to an asset and revisions to maintenance policy that would consider and ensure the cost implications of these changes are well founded. With such a database, tracking of costs with a system/ asset’s age can be monitored and this can lead to decisions such as; continuity, modifications/ renovations and repairs to avoid further cost increases and finally disposal, recycling or replacement of some elements.

### 2.3.2 **Application** and process of LCCA

As mentioned before, LCCA can and is being used by both the private and public sector in the economic evaluation of various possible project alternatives related to asset creation or acquisition. The Australian Asset Management Collaborative Group (AAMCoG) formed in August 2006 by the CRC for Integrated Engineering Asset Management (CIEAM) published a report on LCC Analysis. Below, according to this report is a summary of a common methodology that is a generally accepted framework for LCCA. It can be adapted to a particular purpose of analysis depending on the situation at hand. For example, to assist in planning, budgeting, contracting etc. It is important to also not that each purpose of LCCA may include different factors in the actual life cycle cost aggregation itself but the basic methodology

remains the same and as such can be considered as the best practise for basic structuring of an LCC Analysis application.

a) Plan Life Cycle Cost Analysis

This is an initial planning stage. Here, specific objectives of LCCA are defined and specified and include any assumptions that are made about the facilities/ buildings and their associated costs. In order to shape the analysis for a particular purpose, these objectives of analysis are specified in terms of the outputs which are required by owners or management for decision making.

Limitations, assumptions and constraints which may affect the given alternatives involved in the decision making should be identified at this stage. As the analysis continues, changes in these factors may either increase or reduction the possible project alternatives.

b) Select/ Develop a LCCA model

At this stage a particular LCCA model can be selected since the specific aims and objectives of the process have already been identified during the planning stage. This is when we can realise the different LCC applications and frameworks since each will be designed for its specific objectives. Particularly, the life cycle is broken down based on a Cost Breakdown Structure (CBS) that sets out the particular life cycle phases and relevant cost categories. In many cases, the life cycle is broken down into four stages i.e. acquisition, operation, renewal and disposal. Within each of these phases is an associated set of cost elements that are generally identified through further breaking down the cost categories into smaller groupings. It is also a generally accepted practise that cost elements that do not vary between the given set of alternatives maybe excluded from the LCC calculations. However, it should also be noted that further assumptions may be made that cost elements that are deemed to have an insignificant impact on the calculations can be omitted from the analysis.

After all relevant costs have been identified, a suitable method for estimating each associated costs must then be agreed upon and chosen. Each set of cost elements in any LCC analysis must be assigned numerical cost values in the same unit or currency (for example dollars). Methods of cost estimation are varied and can be determined via a number of different methods.

The Australian/ New Zealand standards guide on LCCA (AS/NZS 4536:1999) lists three main methods which can be used to estimate the cost element values; the Engineering cost method, the Analogous cost method and the Parametric cost method. Despite the fact that all these methods are deterministic in nature, they each estimate the value of the cost element differently.

Engineering cost method

The Engineering cost method is used where there is a detailed and accurate capital and operational cost data for the facility under study. Just like quantity surveying in cost calculations, the engineering cost method involves the direct estimation of a particular cost element by examining the facilities' each individual component at a time which are later summed up together. It uses standard established cost factors such as; firm engineering and/ or manufacturing estimates to develop the cost of each element and its relationship to other elements.

Analogous cost method

The Analogous cost method provides the same level of detail as the Engineering cost method but the difference is that it draws on historical data from components of other assets having analogous size, technology, use patterns and operational characteristics.

Parametric cost method

This method is used in situations where the actual and historical detailed asset component data is limited to only known parameters.

Important to note is that collection of appropriate data is a crucial factor in developing the LCC model. A lot of time and resources is usually dedicated to identifying the required data and sources of this data. This is in fact one of the limitations to the application of LCCA as will be explained later.

c) Apply LCCA model

After having the model ready, cost estimation methods and all required data sources, it is time to perform the actual analysis of the life cycle costs. As long as the model has been developed and estimates made for each cost element, an aggregated LCC value can be evaluated. This value is computed firstly by discounting all cost

elements back to their present day value or average equivalent annual cost values using the standard discounting equation.

According to the State of Alaska – Department of Education & Early Development Life Cycle Cost Analysis Handbook (1999), "Prior to beginning a LCCA, project alternatives need to be established. These alternatives should be distinctly different and viable solutions to the facility issue being addressed." There are reasons that create the need for LCCA and therefore which ever alternatives are to be considered must be able to fulfil these reasons. The most reasonable and cost effective solution to the project problem should be chosen.

Normally before a LCCA can be performed, assumptions must be made especially on how certain values have been obtained as also indicated by The Australian Asset Management Collaborative Group (AAMCoG, 2006) report on Life Cycle Analysis. This helps one to know the level of accuracy of the results. And all assumptions must be used and followed for each of the alternatives to be considered. The State of Alaska Department of Education & Early Development has outlined the basic steps for preparation of LCCA as:

- *A brief description of the project alternatives*
- *A brief explanation as to why the project alternative was selected*
- *A brief explanation of the assumptions made during LCCA*
- *Conceptual or schematic documentation indicating design intent of the alternative*
- *A site plan showing the integration of the proposed facility on the site and the necessary site improvements (for projects involving additions or new construction)*
- *A detailed LCCA of the project alternative*
- *A summary table that compares the total life cycle costs of Initial Investment, Operations, Maintenance & Repair, Residual Value of all the project alternatives.*

According to H. Paul Barringer (2003), LCC follows a process (Fabryck 1991-Appendix A) as shown in figure 2.2 below;

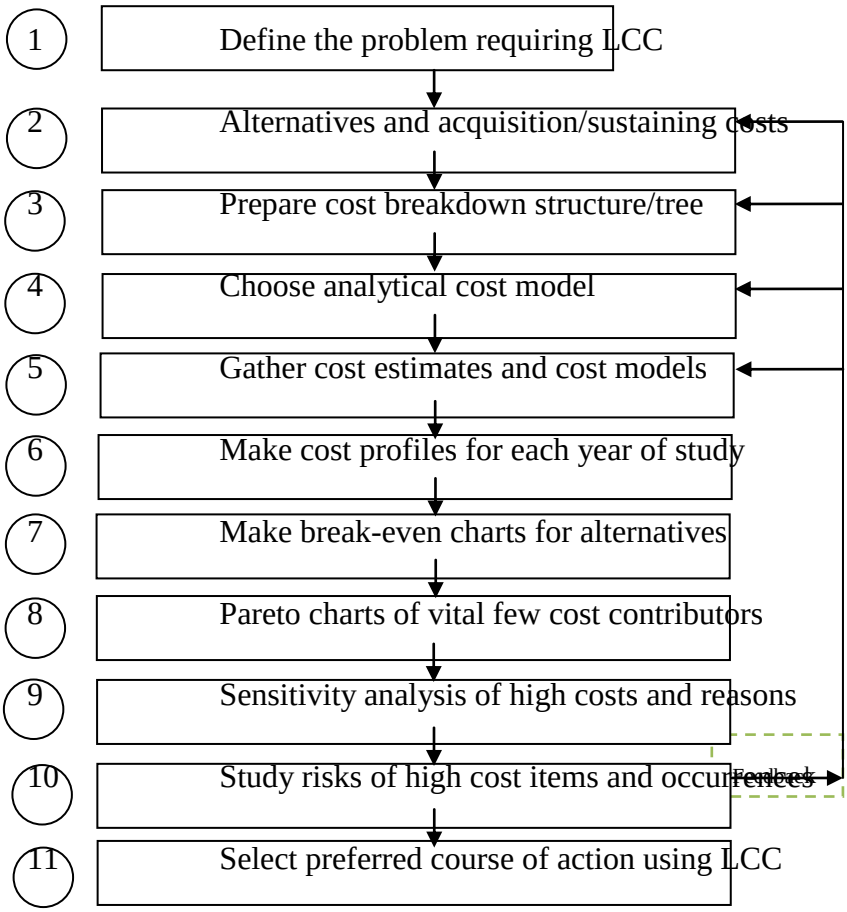


**Figure 2.2:** LCC Process

The steps outlined in the above figure are;

**Step 1**-Identify what has to be analysed and the time period for the project life study along with the appropriate financial criteria.

**Step 2**-Focus on the technical features by way of the economic consequences to look for alternative solutions.

**Step 3**-Develop the cost details by year considering memory joggers for cost structures.

**Step 4**-Select the appropriate cost model, simple discrete, simple with some variability for repairs and replacements, complex with random variations, etc. required by project complexity.

**Step 5**-Acquire the cost details.

**Step 6**-Assemble the yearly cost profiles.

**Step 7**-For key issues prepare breakeven charts to simplify the details into time and money.

**Step 8**-Sort the big cost items into a Pareto distribution to reconsider further study.

**Step 9**-Test alternatives for high cost items such as what happens if maintenance cost is ±10% than planned, etc.

**Step 10**-Study uncertainty/risk of errors or /alternatives for high cost items as a sanity check and provide feedback to the LCC studies in iterative fashion

**Step 11**-Select the preferred course of action and plan to defend the decisions with graphics

### 2.3.3 Required data and information for life cycle cost calculations

Data required for proper Life Cycle costing is not easy to collect and yet it is the most important requirement for the process to be successful. The more the data and information available, the more accurate and successful the LCC Analysis will be. Below is Figure 2.3 (figure 1, Erika Levander, Jutta Schade and Lars Stehn, 2009) which shows categories of data requirements, according to reviewed literature for carrying out LCC Analysis

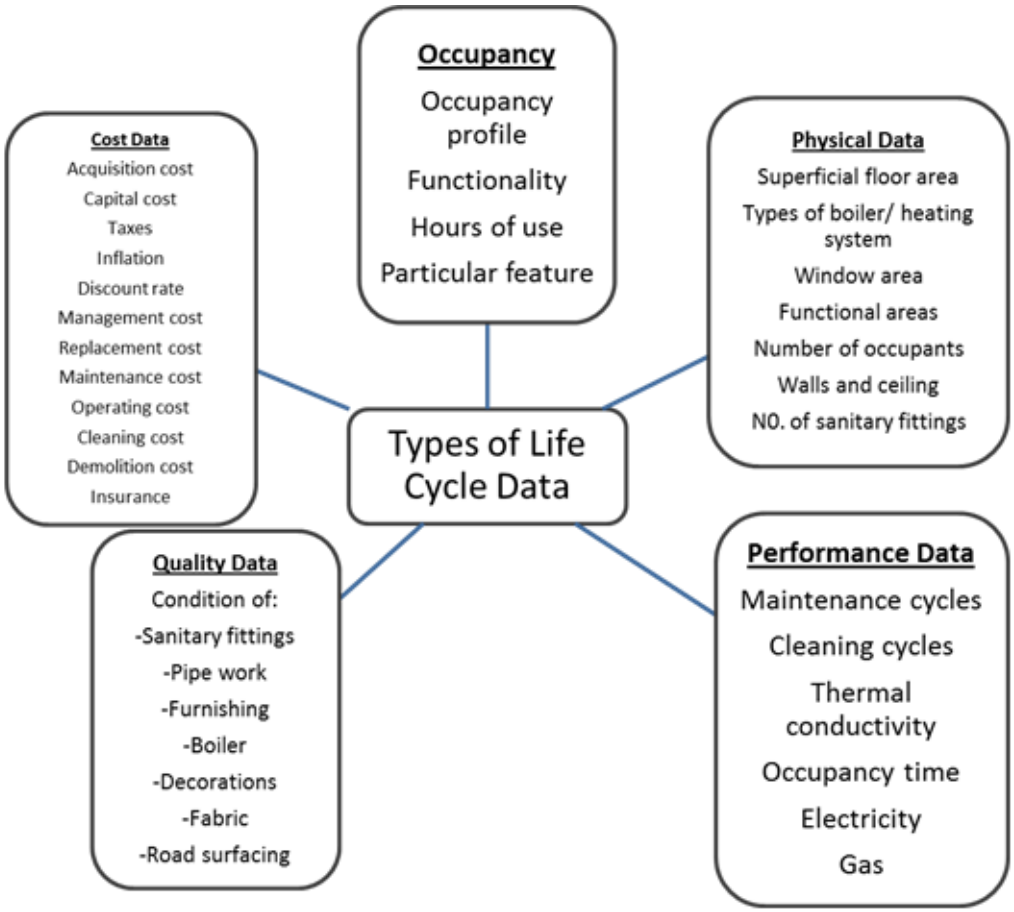


**Figure 2.3:** Categories of data requirements.

In the early stages of design, physical and occupancy data can be used to identify similarities between different projects and determine whether a comparison can be made between them. Flanagan et al (1989) stressed the importance of occupancy data as an equally important key factors especially for public buildings. Performance and quality data are rather influenced by policy decisions such as how well it should be maintained and the degree of cleanliness demanded (Kishk et al., 2003). On the other hand, Quality data are highly subjective and less readily accountable than cost data (Flanagan et al., 1989). As the design gets into a more advanced and detailed stage, life cycle cost estimation is based more on performance and cost data of a building (Bakis et al., 2003). Cost data as will be seen below, would be almost meaningless if they are not complemented by other data types. These data need to be seen in the context of other data categories to obtain a correct interpretation of them (Kishk et al., 2003). Because LCC is a decision making tool, it is important for this data to be presented and compared (for the different options) in a way that will make decisions easy to make.

### 2.3.4 Analysis period

Another important factor concerning data required is the analysis period. This is the period of time over which the Life Cycle costs are to be evaluated. The length of the analysis period which can vary between any given years is dependent on the owner's preference, of course with advice from a building professional. Salway (1986) suggested that the time scale for the analysis should be the least of physical, functional, and economic lives (of the facility). Because the discounting factor applied in the analysis tends to make future costs less significant, there is a general consensus that the analysis period should not be too long. In addition, the uncertainties in the future cannot be effectively defined based on existing data (Davis Langdon Management Consulting 2007).

In the ISO 15686-5, the typical analysis periods are listed as follows:

- The period of foreseeable need or occupation of the constructed asset(the life cycle);
- A period determined by a contractual liability (e.g. for maintenance of the asset or for a mortage financing the investment);

- A standard investment analysis period applied within an organisation;
- If the life cycle of the asset is longer than 100 years, the period of analysis used in the calculations may be 100 years as the calculation is unlikely to be significantly affected beyond this point.

### 2.3.5 Estimate of service life of building components.

Knowing the service life of building components is very important for the anticipation of maintenance, renewal and/ or replacement cycle and their respective costs. This would also be a step towards building sustainability which has become a major concern in the world today. By knowing the components' life times, comparisons would easily be made between the different component alternatives and building as a whole by factoring in the maintenance, renewal and replacement costs. Davis Langdon Management Consulting (2007) suggests that the necessary information about the service life of components can be obtained from:

- ✓ Experience in the use of materials;
- ✓ Testing institutions;
- ✓ Research publications;
- ✓ Manufacturers of building products;
- ✓ Database holders.

### 2.3.6 Sources of data

The data requirements for producing a Life Cycle Cost Analysis are extensive, but lack of relevant data remains one of the main constraints for the implementation of LCC (Sterner, 2000). And yet for an accurate LCC Analysis to be realised, reliable and up-to-date information needs to be gathered for use.

Flanagan et al. (1987) and Boussabaine and Kirkham (2005) listed three major data sources for Life Cycle Costing as follows:

i. Data from manufacturers, suppliers, contractors and testing specialists
    - Material and product suppliers and manufacturers;
    - Government testing bodies;

- Institutions such as Building Research Establishment (BRE), American Society of Civil Engineers.

They say this source of data can be seen as the best guess. Because despite the fact that they (manufacturers, suppliers and testing specialists) may not know how the facilities are used, they may have a detailed knowledge of the performance and characteristics of their material and components.

ii. Forecasting models

If the required data is not available, mathematical models can be developed for analysing costs. Statistical techniques can also be incorporated to address the uncertainties.

iii. Historical data

In the UK for example, the consistent sources such as BCIS (http://www.rics.org/uk/knowledge/bcis/) and SPONS pricebooks are available for cost estimation. Other sources of information they state may include clients' and surveyors' records, and journal papers.

### 2.3.7 Cost breakdown structures for LCCA

LCC includes all costs related to an asset's/ project's different phases of it's life cycle and these costs may vary depending on the particular project/ asset being considered. It may vary due to various reasons such as the reason why these costs are being considered or the available alternatives to be compared. According to H. Paul Barringer (1998) the basic tree for LCC starts a simple tree based on the costs of acquisition and the costs for sustaining the acquisition during its life. This is shown in figure 3 (figure 1. H. Paul Barringer, 1998).

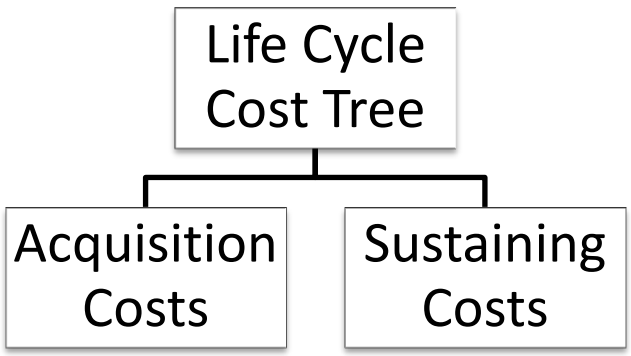


**Figure 2.4:** Basic Tree for LCC.

When an equipment, asset or building system is acquired, it must be sustained throughout its useful life. Therefore, the acquisition costs and sustaining costs are not mutually exclusive because when you acquire an asset you always require extra funds to sustain that acquisition and you also can't sustain without having acquired the asset.

Below, according to figures 4 (figure 2. H. Paul Barringer, 1998) and figure 5 (figure 3. H. Paul Barringer, 1998) which show what costs go into each category of Acquisition costs and Sustaining costs respectively;

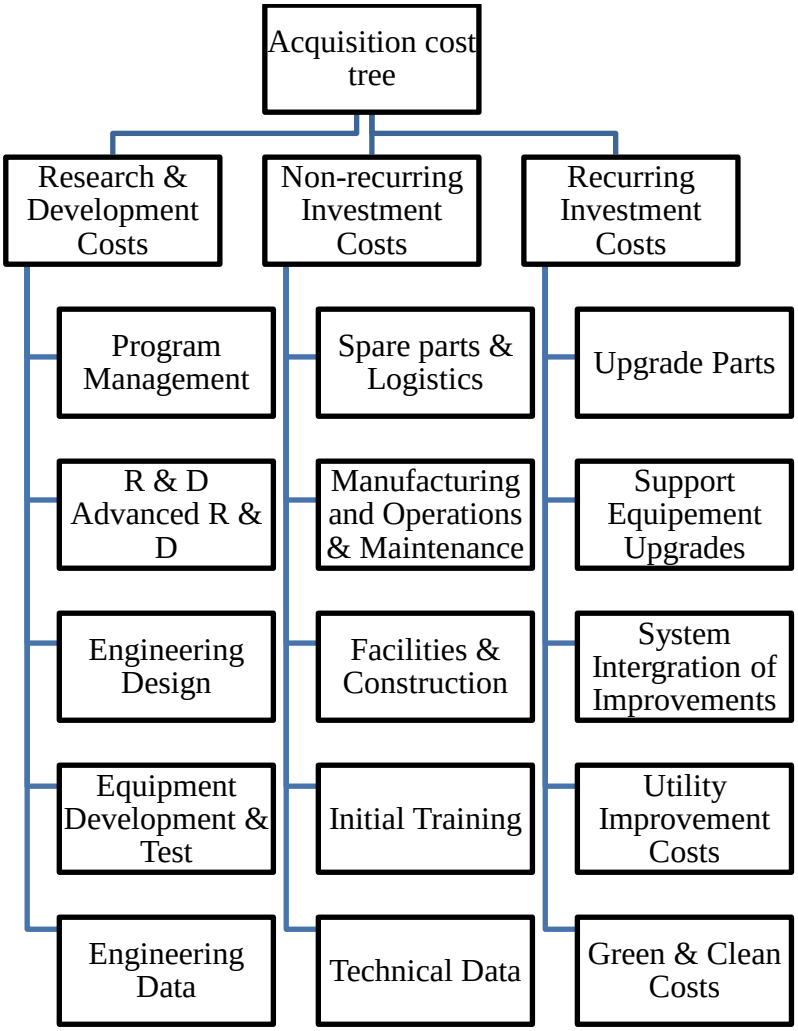


**Figure 2.5:** Acquisition cost tree.

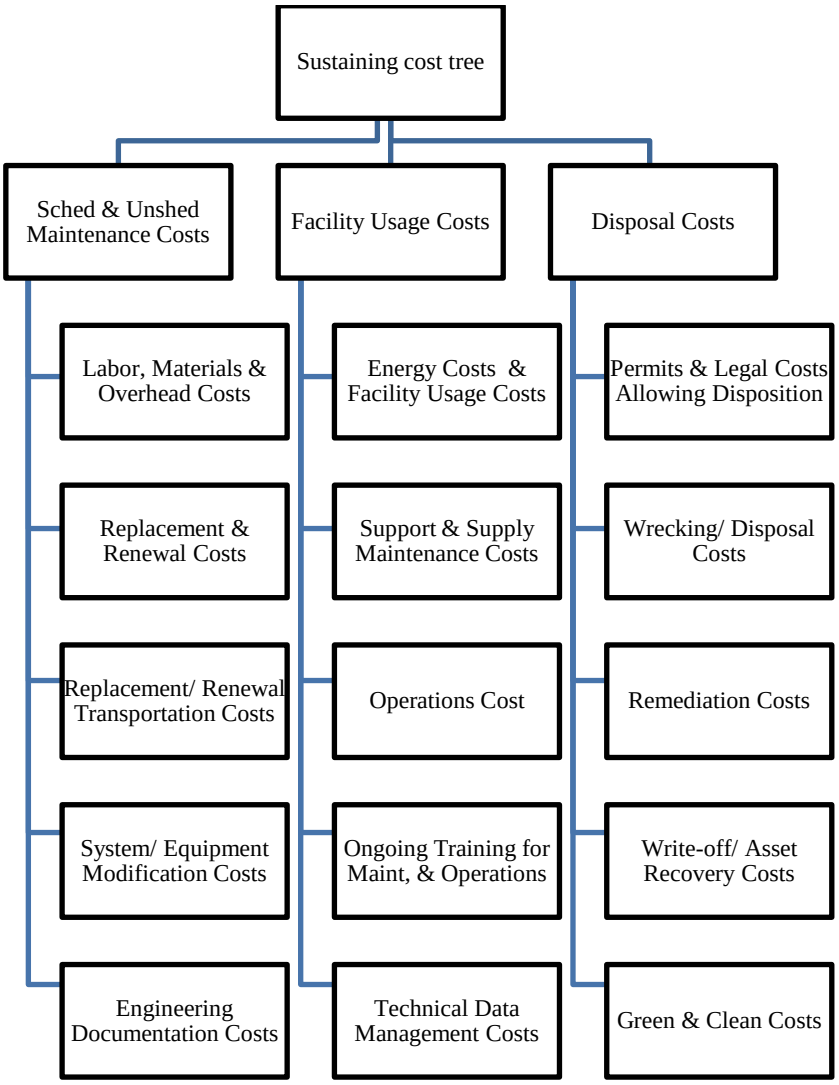


**Figure 2.6:** Sustaining cost tree.

It should be noted that "the cost of sustaining equipment ranges from 2 up to 20 times more than the cost of acquisition" (H. Paul Barringer, P.E. 1998). Therefore the initial costs of acquiring are usually very small and easier to determine compared to the sustaining costs which are more expensive and not obvious to determine.

What exactly goes into acquisition and sustaining cost all depends on the specific case of the project at hand and the organisation to perform the analysis. For example a nuclear power plant to generate electricity will have special categories of acquisition and sustaining costs as compared to construction of an office block or hospital. Or firm A may include certain costs that firm B does not consider necessary for inclusion. Therefore during LCC it is important for one to include the appropriate cost elements and discard the trivial elements that may not have any substantial influence on the out of LCC.

Referring to appendix D, for Life Cycle Cost Categories for State of Alaska - Department of Education & Early Development Alaska School Facilities and appendix E, ISO 15686-5 (ISO, 2006) list of cost categories and variables required, one can realise that cost categories and variables vary from organisation to organisation. In appendix D, the costs are of two types; Initial expenses and Futures expenses. The initial expense includes all the initial investment cost variables while the future expense includes variables of; operation cost, maintenance and repair cost, replacement cost and residual value. Appendix D on the other hand, states variables categorised in groups; acquisition costs, maintenance, operation and management costs and residual/ disposal costs.

## 2.4 Theoretical Economic Evaluation Methods for LCC Analyses.

The core principal in a LCC economic evaluation method is to bring all the various costs that occur at different timings to an equivalent amount for the same select period. Therefore, for input into the calculation, all future costs are converted to their current equivalent by using a suitable discount rate in order to take into account the time value of money. Literature has shown abroad range of economic evaluation methods for LCC Analysis with each having its advantages and disadvantages. It is also important to note that each of these methods has been formed for different purposes and the user should be aware of this.

Below is a table 2.1 (table 1, Erika Levander, Jutta Schade and Lars Stehn, 2009) of reviewed literature by Erika Levander, Jutta Schade and Lars Stehn, (2009) that gives a brief summary of the advantages and disadvantages of different economic evaluation methods of LCC. It also gives brief information about what each method calculates and what it is usable for;

**Table 2.1**: Methods of Life Cycle Costing (table 1, Erika Levander, Jutta Schade and Lars Stehn, 2009).

| Method | What does it Calculate | Advantage | Disadvantage | Usable for |
|---|---|---|---|---|
| **Simple Payback** | Calculates the time required to return the initial investment. The investment with the shortest payback time is the most profitable one (Flanagan et al., 1989). | Quick and easy calculation. Result easy to interpret (Flanagan et al., 1989). | Does not take inflation, interest or cash flow into account (Öberg, 2005, Flanagan et al., 1989). | Rough estimation to see if the investment is profitable (Flanagan et al., 1989). |
| **Discounted Payback method (DPP)** | Basically the same as the simple payback method, it just takes the time value into account (Flanagan et al., 1989). | Takes the time value of money into account (Flanagan et al., 1989). | Ignores all cash flow outside the payback period (Flanagan et al., 1989) | Should only be used as a Screening device, not as a decision advice (Flanagan et al., 1989). |
| **Net present value (NPV)** | NPV is the result of the application of discount factors, based on a required rate of return to each years projected cash flow, both in and out, so that the cash flows are discounted to present value. In general, if the NPV is positive it is worthwhile investing (Smullen and Hand, 2005). But as the focus in LCC is on cost rather than on income, the usual practice is to treat cost as positive and income as negative. Consequently, the best choice between two competing alternatives is the one with minimum NPV (Kishk et al., 2003). | Takes the time value of money into account. Generates the return equal to the market rate of interest. It uses all available data (Flanagan et al., 1989). | Not usable when the comparing alternatives have different life lengths. Not easy to interpret (Kishk et al., 2003). | Most LCC models utilize the NPV method (Kishk et al., 2003). Not usable if the alternatives have different life lengths (Flanagan et al., 1989). |
| **Equivalent annual cost (ECA)** | This method expresses the one time NPV of an alternative as a uniform equivalent annual cost. For that it takes the factor present worth of annuity into account (Kishk et al., 2003). | Different alternatives with different life lengths can be compared (ISO, 2004). | Just gives an average number. It does not indicate the actual cost during each year of the LCC (ISO, 2004). | Comparing different alternatives with different life lengths (ISO, 2004). |
| **Internal rate of return (IRR)** | The IRR is a discounted cash flow criterion which determines an average rate of return by reference to the condition that the values be reduced to zero at the initial point of time (Moles and Terry, 1997). It is possible to calculate the test discount rate that will generate an NPV of zero. The alternative with the highest IRR is the best alternative (ISO, 2004). | Results get presented in percentage which gives an obvious interpretation (Flanagan et al., 1989). | Calculations need a trial and error procedure. IRR can only be calculated if the investments will generate an income (Flanagan et al., 1989). | Can only be used if the investments will generate an income, which is not always the case in the construction industry (Kishk et al., 2003). |
| **Net saving (NS)** | The NS is calculated as the difference between the present worth of the income generated by an investment and the amounted invested. The alternative with the highest net saving is the best (Kishk et al., 2003). | Easily understood investment appraisal techniqu | NS can only be used if the investment generates an income (Kishk et al., 2003). | Can be used to compare investment options (ISO, 2004). But only if the investment generates an income (Kishk et al., 2003). |

Most LCCA models use the PV (present value) method because it takes the time value of money into account and generates the return equal to the market rate of interest. With this method, it is possible for one to determine the costs incurred for each year at today's rate. Thus yearly costs of different project alternatives can be compared.

İt is important to note that the definition of the term NPV involves both in and out cash flows as stated in table 2.1. This means that incomes are included. However, for LCCA calculations, incomes are excluded. Therefore for LCCA calculations, the term Present Value (PV) with the same definition as NPV but excludes incomes should be used rather than the use of NPV.

However, when projects with different lives are being compared, the Equivalent Annual Cost method is the most suitable to use. It expresses the one time NPV of an alternative as a uniform equivalent annual cost by taking the factor present worth of annuity into account. In this case, it expresses the PV of an alternative as a uniform equivalent annual cost. It therefore gives an annual average cost for each alternative hence enabling comparison of projects alternatives with different lives.

### 2.4.1 Discounting formulas

Discounting techniques enable one to account for the timing of cash flows and the associated costs of money. By using discounting formulas, all benefits and costs estimated for future years must be converted to present values or annual values to account for the time value of money. They can also be converted to a specific time in the future. Converting these cash amounts to equivalent values (discounting) at a given time is performed by applying discount formulas, or corresponding discount factors, to benefit and cost data associated with a given project alternative for investment.

The reason for discounting is because the costs and benefits of buildings are typically spread over time, they must be adjusted to a common time basis before they can be aggregated to determine a single value thus the economic performance. Discounting is performed by applying discount (interest) formulas or corresponding discount factors calculated from the formulas, to the estimated costs and benefits that result from a given investment.

Steps in Discounting:

a) Determine the;

- Discount rate to be used
- Time period to be considered for LCCA

b) Insert into respective Discounting Formula

c) Apply to Amount in question

d) Find Equivalent Value at desired Time

There are specific formulas for each kind of cash flow and some of these include the following;

- To find the present value equivalent of a single amount to be received in the future, the single present value formula (SPV) is used (**2.1**).

$$P = S\,[1/(1+i)^n] \qquad \textbf{(2.1)}$$

- To find the present value equivalent of a uniform series of future cash amounts, the uniform value formula (UPV) is used **(2.2).**

$$P = R\,[((1+i)^n - 1)/\, i(1+i)^n\,] \qquad \textbf{(2.2)}$$

- To find the same value in the future of a single cash amount received today, the single compound amount formula (SCA) is used **(2.3)**.

$$S = P\,(1 + i)^n \qquad \textbf{(2.3)}$$

- To express a future value as a same uniformly recurring annual value, the uniform sinking fund (USF) is used **(2.4)**.

$$R = S\,[\,1/\,(1 + i)^n - 1] \qquad \textbf{(2.4)}$$

- To find the same value in the future of a stream of uniform cash amounts over a period of years, the uniform compound amount formula (UCA) is used **(2.5)**.

$$S = R\,[((1+i)^n - 1)/\,1\,] \qquad \textbf{(2.5)}$$

- To express a present value as a same uniformly recurring annual value, the uniform capital recovery (UCR) is used **(2.6)**.

$$R = P\,[\,(i\,(1 + i)^n)/\,(1 + i)^n\,\text{-}1] \qquad \textbf{(2.6)}$$

Whereby;

***i*** represents an interest rate per interest period

***n*** represents a number of interest periods

***P*** represents a present sum of money

***S*** represents a sum of money at the end of ***n*** periods from the present date that is equivalent to ***P*** with interest ***i.***

***R*** represents the end-of-periods payment or receipt in a uniform series continuing for the coming ***n*** periods, the entire series equivalent to ***P*** at interest ***i***

### 2.4.2 Selection of a discount rate

Discount rates may be expressed in either "nominal" or "real" terms whereby a nominal discount rate includes both the effects of inflation and the real earning power of money invested over time while a real discount rate reflects only the real earning power of money, and therefore is lower than a nominal rate would be, given the same conditions. A real rate is generally considered appropriate for evaluating investments if the general rate of inflation is not included in future cash flows. On the other hand a nominal rate is appropriate if cash flows are inflated. Below is the relationship between a nominal discount rate and a real discount rate:

Real Discount Rate= (1 + nominal discount rate/1 + general price inflation rate) - 1

As noted by Barringer (1996), generally the most difficult question in any LCCA application is which discount rate to apply. The analysis and eventual conclusions of an LCCA application can be greatly impacted upon by the discount rate used. For example, if the discount rate for a particular alternative is set too low a valid project option may be rejected, and vice versa (AAMCoG (Australian Asst Management Collaborative Group), 2008). It is therefore of great importance to apply the right discount rate for each particular situation.

The discount rate may reflect the effect of only real earning power of money invested over time or it may also reflect the effects of inflation (Woodward, 1997). One justification for either using real or nominal rates was that for public assets, benefits should depend only on real gains. However, it was also noted that price change effects from nominal cost values & rates can be factored out, or nominal rate values

can be used as long as there is maintained consistency throughout. However, most literatures seemed to base LCC calculations on the constant real discount rate and real value.

Whichever rate is selected, it is important that an accurate value is selected. It will depend on the entity in question, the asset being examined and the point in time at which the cost is being incurred. Both for the LCCA Better Practise Guide released by the Australian Audit Office (2011) and the Australian/New Zealand standards guide, a rate is selected which reflects the risk-adjusted rate of return on the asset which justifies the long-term retention of the asset by the entity. According to Davis Langdon Management Consulting, (2007), the following methodologies have been observed from various literatures on how to select an appropriate discount rate;

- At the current or expected rate the organisation must pay for the use of its borrowed funds;
- At the rate of return that could be expected from loaning of money, but which is denied to the organisation by the need to fund its own projects (sometimes referred to as opportunity cost);
- At the lowest rate of industrial borrowing for a financially sound, well established company;
- At test discount rate can be used based on the assumption that when inflation rates are reasonably low there is a stable relationship between inflation and base rate, implying a real discount of 4%;
- Investments in long term treasury bonds can be assumed to have no risk. Therefore, the discount rate can be taken as the Treasury bond rate less an allowance for the expected rate of inflation.

An appropriate discount rate will therefore vary from firm to firm and will need tobe determined by competent individuals with good financial skills. Factors both internal and external will affect what discount rate is finally selected. For example, the Guidance on Life-Cycle Cost Analysis(2003) released by the Federal Energy Management Program suggests a rate based on the 12 month average of the composite yields of all outstanding US treasury bonds (AAMCoG, 2008.) It is therefore not clear and there is lack of an appropriate level of guidance or framework

for the actual discount rate value selection. There needs to be a more uniform and universal approach to selecting a discount rate for LCC Analysis.

### 2.4.3 LCC formulas

The LCC formula applied as mentioned earlier will vary depending on the organisation's cost categories, the purpose of the procedure or the nature of project alternatives at hand. For example, the model from the American Society for Testing Materials distinguishes between energy and other running costs. This is useful in adopting different discount rates for different cost items:

Generally, a LCC formula is the summation of; initial costs, construction costs, maintenance and repair costs, operation costs occupancy cost and a negative residual cost or value. The residual value must be subtracted from all other costs because it is the remaining value of the building and therefore an income that must be deducted from expenditure. As indicated in the literature review, what lies under each of these cost categories may vary from organisation to organisation. Some may even create extra cost categories or combine so of the above in order to suite their criteria.

However, each of the above mentioned cost must be discounted using an appropriate discount rate to either a present value (PV) or an equivalent annual cost value (EAC). This will depend on whether the project alternatives being compared have the same life time or different lives. As mention earlier, for projects with the same lives the NPV method is the easiest and most commonly used and for projects with different lives, it is advisable to use the EAC method.

## 2.5 Uncertainty Considerations in Life-Cycle Cost Analysis.

Most decisions about building-related investments involve a lot of uncertainty about their costs and potential savings. Despite the fact that performing an LCCA greatly increases the likelihood of choosing a project that saves money in the long run, there may still be some uncertainty associated with the LCC results. Because LCCAs are usually performed early in the design process, only estimates of costs are available, rather than certain expected expenditure amounts. Uncertainty in input values means that actual outcomes may differ from estimated outcomes.

Therefore, there are techniques for estimating the cost of choosing the "wrong" project alternative. Deterministic techniques, such as sensitivity analysis or breakeven analysis, are easily done without requiring additional resources or information. These two methods produce a single-point estimate of how uncertain input data affect the analysis outcome. Probabilistic techniques, on the other hand, quantify risk exposure by deriving probabilities of achieving different values of economic worth from probability distributions for input values that are uncertain. However, they have greater informational and technical requirements than do deterministic techniques.

Whether one or the other technique is chosen depends on factors such as the size of the project, its importance, and the resources available. Since sensitivity analysis and break-even analysis are two approaches that are simple to perform, they should be part of every LCCA.

### 2.6 Difficulties and Limitations of Performing LCCA

The application of LCCA has some difficulties and hardships involved. Below are some of these limitations as observed from the various literatures reviewed:

**Data collection;** a lot of data, both accurate and appropriate has to be collected to enable a proper LCCA. The data types may include; cost data, quality data, occupancy data, performance data, and physical data of a facility and its individual components. Therefore a lot of time and resources has to be dedicates to this thus making it a limitations. And yet the more the data and the more accurate it is, the more reliable the results of the LCCA.

**Discount rate determinations;** Determination of what discount rate to use for the analysis still remains a challenge despite the many studies already made. Possible applicants see this as a limitation because the discount rate to be used will significantly impact on the outcome of the LCCA. Therefore in case a wrong discount rate is used, a wrong or an alternative that is not the best maybe chosen due to an error in the results.

**Uncertainties of future costs;** LCCA is best done as early as possible before any alternative is selected. But a lot of future costs and information has to be determined so that a proper comparison can be made. However, there are a number of

uncertainties that affect the determination of future values. This too presents possible challenges and difficulties.

**Intangible aspects of a project;** LCCA is a technique that uses tangible values such as cost of a project. However projects have intangible value such as aesthetic and comfort levels. It is therefore difficult to combine the results from LCCA with the intangible aspects of the project and this is still a challenge

**Ignorance of clients;** A number of construction clients are ignorant and unaware of the benefits of LCCA. They therefore give it a low priority in their demands thus its limited practise.

## 2.7 Conclusion of Literature Review

The different literatures have defined LCCA in more or less the same way but with different wording. There is a consensus that it is an analysis that takes into account all related costs in the life cycle of any facility or asset in question. From the acquisition of land, to the construction of the facility, to it's operation, maintenance and repair, to its renovation and finally disposal at the end of its useful life.

LCCA has been acknowledged as a decision making tool to enable owners and professionals to select between different alternatives that aim at providing the same objectives and benefits. It is not only applicable for the construction industry but all other industries. The best option is the one with the least total cost to be incurred after its use or after the given period of the analysis. A lot of data and information about each option involved is necessary for the successful application. Different sources of data have been documented such as from suppliers and manufacturers, forecasting models and from historical archives. Collection of data has been stress as one of the difficulties to perform the analysis.

The period of time for which the LCCA can be performed varies depending on the nature of projects in consideration and their objectives. Some LCCA handbooks and organisations may have a standard period of time stipulated for a LCCA. But this varies from firm to firm depending on the requirements.

Cost categories created for LCCA also vary from organisation to organisation. But at the end of the analysis, all cost elements are included even though some may be in different categories. Sometimes costs that are similar in value for all alternatives or

costs that do not make a significant difference in the final outcome are not included in the LCCA. Therefore it is apparent from literature sources that the final set of cost elements which are included in the analysis depend greatly on the purpose of the application. For example depending on the asset being assessed, disposal costs may be replaced by a salvage value. However all this should be noted at the planning stage of the analysis.

Determining which discount rate to use has been noted as a contentious issue. From the literatures, there is no clear guideline on how one can determine which discount rate to use between the real and nominal interest values. However, there is a general linage towards the use of the real interest rate. But even then, what exact value and what should be considered to determine it is still not clear. Further studies and research are required on determining the right discount rate to use because it significantly affects the outcome. Therefore, with a wrong discount rate a less favourite alternative maybe chosen for execution.

Finally, LCCA is seen as a tedious process that needs a lot of time and resources to be allocated to its application. But, if it is well applied, the benefits are worth the effort.

# 3 QUESTIONNAIRE DESIGN AND THE SURVEY

## 3.1 Questionnaire Design

### 3.1.1 Overview

The aim of the research is to propose a checklist that can be used for Building Life Cycle Cost Analysis in Uganda. And to achieve this certain objectives must be met and these include:

a. To review current literature on Life Cycle Cost Analysis.
b. To find out what information is necessary and/ or used for Life Cycle cost analysis in the developed world.
c. To find out whether Life Cycle Cost analysis is practised in Uganda and what information and data is used and how it is done.
d. To compare the LCC Analysis practise in Uganda with the developed world and existing theoretical literatures.
e. To propose a Checklist for Building Life Cycle cost analysis in Uganda.

Objectives **a** and **b** were achieved by the literature review whose contents have been stated and discussed in the previous chapter (2 LITERATURE REVIEW). The questionnaire focused first on achieving objective **c**. The questions asked were with the intention of extracting information on whether Life Cycle Cost Analysis is practised in Uganda. And whether it is practised or not, what information is available for Building Life Cycle Cost Analysis and how this information is used by the building professionals in Uganda. To achieve objective **d**, the information and data gathered from the questionnaire forms was then used to compare with what has been mentioned and gathered from the literature review. After this comparison and discussion was made, the last objective, **e,** was achieved through a proposed checklist for Building Life Cycle Cost Analysis in Uganda. Therefore, a mixture of a structured and unstructured questionnaire was designed to suit the above stated research aim and objectives.

This research can generally be seen as a mix of both qualitative and quantitative as will be seen in the kind of questions asked. A total of 29 questions were asked. Closed typed, semi- closed typed and opened ended questions were used in the questionnaire. In this case semi-closed type refer to those questions which give the responder an option (besides the stated ones) to give their own response. Closed type were 2, semi-closed 22 and open type questions were 5. Below is figure 3.1 showing the percentage of each:

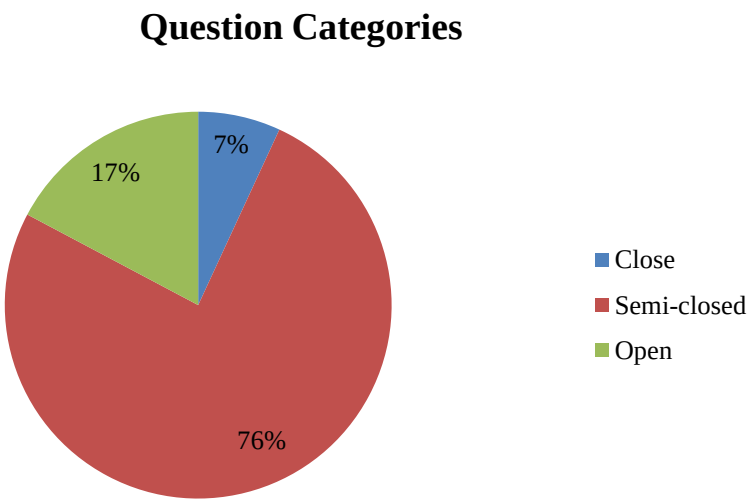


**Figure 3.1:** Question catergories (n=27).

The reason for having most of the questions open and semi-closed was to allow the respondents give the researcher as much information as possible to enable the researcher to achieve his aim and objectives.

A brief or introduction about this research was prepared and given to the responder together with the questionnaire form. The purpose of the brief was to give the responders a brief background of the topic at hand and to provide the reasons and intentions of the research. A summary of the methodology used was also contained in the brief. A sample of the brief and questionnaire is appended in Appendix A and B respectively.

### 3.1.2 Sections of the questionnaire

The questionnaire was divided into two sections:

**Section 1**

Section 1 contains 6 questions and was aimed at gathering general background information about the responder. This helped the researcher understand the responders better:

**Question 1**: It is to ask the profession of the respondents. By knowing the profession of the responder, it gives more reliability to the data as it will indicate which area of the built environment they specialise.

**Question 2**: It is to ask what kind of work the responder's company or institution does. It may be involved in architectural, engineering, contracting, quantity surveying, project management works or in government works. This would indicate what point of view they have concerning the Life Cycle Cost Analysis topic.

**Question 3:** It was to ask how long the responder has been practising in the built environment field. There more experience in the construction field, the more the data given will be perceived reliable.

**Question 4:** It was to ask what kind of projects they normally engage in. residential, commercial, public, hotels or other. This questions aims at finding out whether the kind of project has a relation to whether or not LCCA is performed.

**Question 5:** It was to ask the level of educational background the responder's clients have. This will enable the research find out where the client level of education has a relation to the demand to perform LCCA.

**Question 6:** It was to ask how many projects the responder and their firms have actively participated in or done. This will enable the research understand whether the number of projects done has a relation to the performance of LCCA.

**Section 2**

Section 2 of the questionnaire contains questions that relate directly to the topic of Building Life Cycle Cost Analysis and Management.

**Question 7:** Asks whether the responder is familiar with the concept of Life Cycle Cost Analysis and Management. This will determine how reliable the next answers will be.

**Question 8:** Asks the responder to give a brief state on what LCCA and management means to him/her and the respective organisation. This will also enable the research hypothese what the next responses will be.

**Questions 9 & 10:** They were to ask whether the responder and his or her colleagues are aware of the benefits of LCCA.

**Questions 11 & 12:** They were to ask whether LCCA is done for the responder's projects and whether his/her firm has someone specifically responsible for it. It will enable the research know if LCCA is being gone.

**Questions 13**: It was to ask whether the clients ever demand for a LCCA. This would explain if LCCA is done due to client demands.

**Question 14:** It was to ask whether the concept of LCCA is part of the curriculum at Built Environment departments in Universities. This would tell whether Ugandan graduates are aware of LCCA and its benefits.

**Question 15:** It was to ask what evaluation methods are used during selection of different options. This would inform the researcher what else besides or in conjuction with LCCA is used to aid decision making.

**Question 16:** It was to ask what sources of information are there to aid the methods stated in the previous question's response. The research will learn the data and information sources in Uganda.

**Questions 17, 18 &19:** They were to ask where one can access this information and its accuracy. The research will know to what extend this information is accessible and its reliability.

**Question 20, 21 & 22:** They were to ask why clients don't demand for LCCA, whether they are informed about its benefits and why they are not informed if so, respectively. This would enable the research know whether it is the clients or the building professionals to blame for the lack of LCCA practise in Uganda.

**Question 23:** It was to ask if there is any guide or model for LCCA in Uganda. This would give the research a starting point to propose a checklist or use it as a basis if there was one.

**Question 24 & 25:** They were to ask whether is is necessary to perform LCCA in Uganda and why. This would give the responders view on the need for LCCA in Uganda.

**Question 26:** It was to ask what the responder thinks is the reason professionals are not performing LCCA. This would enable the responder understand some of the hindrances to the performance of LCCA in Uganda.

**Questions 27, 28 & 29:** They were to ask the responder to give their views on what can be done to encourage the LCCA practise, what they recommend and general advice they can give the researcher. The researcher would be able to get ideas from

professionals operating in Uganda about what can be done to make LCCA a common and appreciated practise.

### 3.2 The Population

The survey population was comprised of building professionals operating or with offices within the central region of Uganda. It is important to note that most of these professionals may have done or are currently handling projects in other parts of the country. The central region was chosen because this is the most developed region in Uganda and most of the big and more advance professional firms and professionals have their bases here. It is also home to Uganda's capital city and majority of higher learning institutions. It was therefore seen as the best region to collect useful data for this research.

Below is figure 3.2 that shows the different regions of Uganda;


**Figure 3.2:** Map showing regions of Uganda.

Purposive sampling was used. The researcher specifically chose who to interview with the aim of generating relevant information to aid in this research. Because Life Cycle Cost Analysis is a concept that is still gaining moment in its application (even in the developed world), the researcher thought it wise to purposively choose responders to interview since the research was being done in a developing country. Uganda as a country is still behind in a great number of sectors, and this includes the construction sector. Therefore, the nature of the information and data sought needed to be obtained from a selected sample space. Professional bodies such as the Uganda Society of Architects and the Institution of Surveyors of Ugandan provided a list of registered and practising members from which the research was able to pick most of the population sample. The following are the criteria used to select who to send the questionnaire to (/responders):

- Place of work.

Professionals that are both practising in the field and part of the academia at various universities were taken as a target sample. The research thought that these professionals would be in good position to combine both their academic practise knowledge and experience in the field to give reliable information in accordance with the questionnaire questions.

Professionals that are also working with government institutions such as ministries, the army and city councils were also a target group. Their response would bring in responses from the government's or local authorities' points of view. It would also inform the research what is happening in government and local institutions as concerns to LCCA.

- Experience and Known public works

Professions or firms whose work is well known and recognised in the public domain in Uganda as generally successful were also a target group. They may have for example been part of a team that participated in the construction of some of the country's most outstanding structures. This presents a perception that important information can be got from them.

These professionals or firms are also known as some of the oldest in the country hence the perception that they would provide useful information to this research.

- Recommendation by fellow professionals

As the researcher distributed questionnaire forms and gather information and data, some responders advised him on whom else or who best to interview for such data because of the perception that more accurate and reliable information can be got from them. So such professionals and firms were also part of and included in the purposive sample.

- Academic qualifications

Professional bodies such as the Uganda Society of Architect (U.S.A) on an annual basis publishes a list of all registered members with their contacts, places of work and academic qualifications. It is this list that the researcher used to single out possible interviewees by looking at their academic qualifications and considering those with;

    - Qualifications more than a first degree in Architecture,
    - Project and/or construction management postgraduate studies,
    - PHD degrees and those
    - With degrees obtained from abroad (outside the East African region.)

- Personally known.

The research also contacted responders who are known to him personally as former work colleges, former employers, former lectures or acquaintances. But only those the responder thought would give important information were contacted.

### 3.3 Survey Statistics

There were 70 sets of questionnaires sent out to building professionals and firms in Uganda. The target professionals were Architects, Quantity surveyors, Engineers, Project Managers, Contractors and academicians who are registered and practising professionals in any of the former fields. 27 sets of the sent questionnaires were returned filled. Refer to Table 3.1 for Summary Response of Survey.

**Table 3.1:** Summary Response of Questionnaire forms.

| **Number of questionnaires sent** | **Number of questionnaires return as filled** | **Number of questionnaires return as filled** |
|---|---|---|
| **70** | 27 | 38.57% |

Majority of the questionnaire respondents were architects and quantity surveyors. These were also the biggest number to whom the questionnaires were sent to. This is because in Uganda, the project management profession has not yet picked up so it is mainly the Archictects that take on this role. Thus they are generally responsible for the projects from the initial stages completion which makes them the professionals in the best position to give reliable responses. The quantity surveyors in the same respect are the ones who are brought on board by the architect (rarely by the client) to deal with the issues related to cost. They are therefore also the right professionals to fill the questionnaire form since they specialise in cost related issues. Below is table 3.2 which shows the percentage of each profession and their responses;

**Table 3.2:** Frequency Statistics.

| Professional Background/ work | Number of questionnaire sent out | Percentage of questionnaires sent out | Number of responses returned | Percentage of questionnaires returned |
|---|---|---|---|---|
| Architects | 28 | 40 | 12 | 44.4 |
| Quantity Surveyors | 24 | 34.3 | 8 | 29.6 |
| Engineers | 14 | 20 | 5 | 18.5 |
| Business/ Contractors | 4 | 5.7 | 2 | 7.5 |
| Total | 70 | 100% | 27 | 100% |

Below **figure 3.3** shows a summary of the percentages of responses received from each profession.

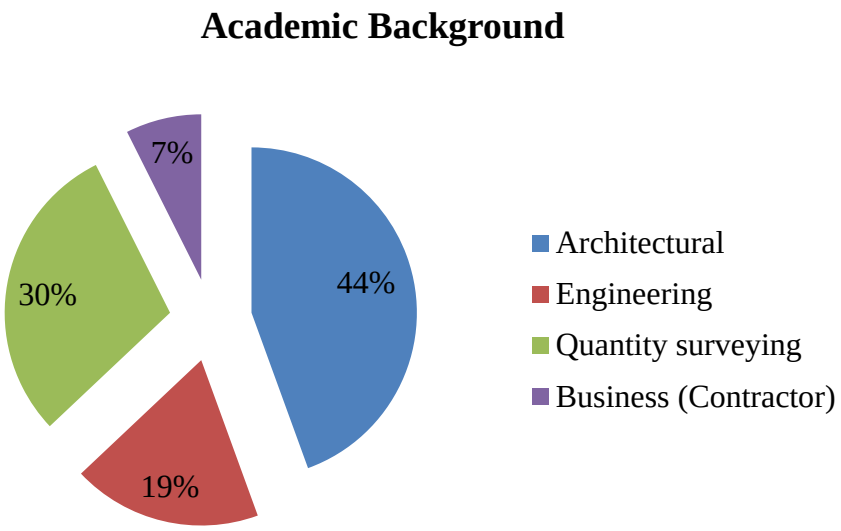


**Figure 3.3:** Academic Background (n=27).

Many of the respondents perform more than one nature of works at their place of work. 11 said they do architectural works, 8 engineering works, 9 contracting works, 9 quantity surveying works each, 1 government works and 1 stated other works. The latter specified the other works as project management and property development and investment. Below, figure 3.4 shows the percentage share of work done by the respondents:

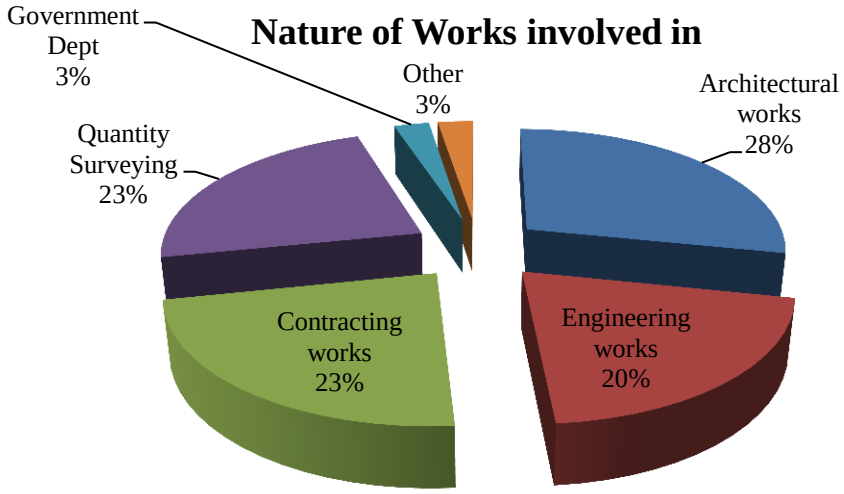


**Figure 3.4:** Nature of works responders do (n=27).

On how long they have been working and practising in the built environment, majority of the respondents have work for between 5-10 years. Table 3.3 shows statistic for the respondent's experience:

**Table 3.3:** Experience of responders.

| Years of Experience | Number | Percentage |
|---|---|---|
| Less than 2 | 0 | 0% |
| 2 - 5 | 3 | 11% |
| 5 - 10 | 13 | 48% |
| 10 - 20 | 6 | 22% |
| More than 20 | 5 | 19% |
| Total | 27 | 100% |

The respondents have worked and participated on different kinds of projects which include but are not limitted to; residential, commercial(hotels, shopping malls, restaurants etc), offices, public (schools, hospitals, governmentals) and industrial projects. And most of their clientele can be categorised as literate.

Table 3.4 shows the number of projects the respondents said they have so far participated on with there firms and institutions of work;

**Table 3.4:** Number of projects done.

| Projects | Number | Percentage |
|---|---|---|
| Less than 10 | 2 | 7% |
| 10 - 20 | 3 | 11% |
| 20 – 50 | 8 | 30% |
| 50 - 100 | 5 | 19% |
| More than 100 | 9 | 33% |

The figure 3.5 below expresses this in percentage form

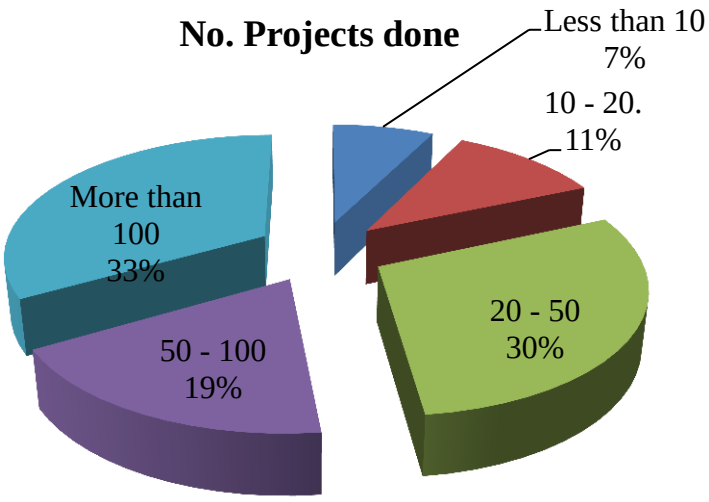


**Figure 3.5:** Number of projects done (n=27).

## 4. ANALYSIS AND DISCUSSION OF THE RESULTS

### 4.1 Understanding of the Concept of Life Cycle Cost Analysis

The concept of Life Cycle Analysis is still new in Uganda and Africa as a whole. 19 of the respondents said they were familiar with the concept, 3 were not and 5 said they have heard about it but have never bothered to apply it. Most responders said they were not sure if their colleagues in other firms know about this concept. Refer to figure Table 4.1 and Figure 4.1 below for this statistic:

**Table 4.1:** Level of Familiarity with LCCA concept.

| Familiarity | Number | Percentage |
|---|---|---|
| Yes | 19 | 70% |
| No | 3 | 11% |
| Heard of it but never applied it | 5 | 19% |
| Total | 27 | 100% |

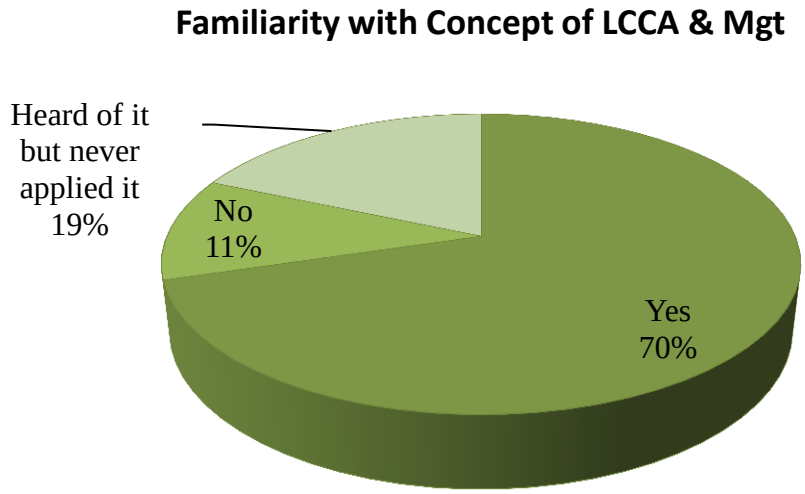


**Figure 4.1:** Level of Familiarity with LCCA concept (n=27).

All those who said they were familiar with the concept stated clear and correct definitions for it that were similar to those in the literature review. Some of their definitions and explanations included:

Life Cycle Cost Analysis & Management is an imperative economic analysis used in the selection of options that affect both anticipated and future costs of a project. It evaluates preliminary investment choices and classifies the least cost options for a twenty year period. But it should be noted that the period of the analysis is not restricted to 20 years. It varies depending of the project and objective of the analysis.

It is the selections of materials, plant equipment and components which whilst not exceeding established budgets, will provide a building which will operate economically and minimum maintenance cost, minimum recurring expenditure and length of life for the specified building.

Life Cycle Cost Analysis (LCCA) is a method for assessing the total cost of facility ownership. It takes into account all costs of acquiring, owning and disposing of a building or building system. It is especially useful when project alternatives that fulfil the same performance requirements, but differ with respect to initial costs and operating costs, have to be compared in order to select the one that maximizes net savings. Application of this methodology by a firm / consultancy such as ours would support a holistic and environmentally conscious design and project management approach, which should result in overall net savings in the long term for our clientele. It would also lead to sustainable design and project management.

Design decisions (including alterations in construction) have a short and long term cost implication. For a client to get the optimal cost benefit balance in a project, design decisions have to be evaluated on both scales - the short and long term. This requires analysis of available data on performance of materials, configurations, technologies etc...used in design. Most of the decisions nevertheless are made based on prior experience or producers' specifications without rigorous scientific analysis. Decisions are made this way because it is costly and time consuming to collect and/or investigate their effectiveness and to thereby develop norms of action. At times, decisions may be made out of ignorance in the absence of better options.

An investment management tool that assists decision making by comparing and analysing capital costs against costs in use over a given period of an investment.

Main points to pick from the definitions and understanding of Life Cycle Cost Analysis by the responders and from the literature review include the following:

- It is a decision making tool between different alternatives that aim at providing the same objectives and benefits.
- It considers all costs from acquisition through construction to operation, maintenance, repair & replacements/ renewal and finally to disposition.
- A lot of data and information about each option involved is necessary for the successful application.
- It can be done over a specified period of time that is determined depending on the nature of projects in consideration and their objectives.
- It can either be done for selection of each building component or project as a whole.
- Cost values involved must all be converted through discounting to the same time value of money before they are aggregated.

Majority of the respondents representing 48% stated that they partially perform LCCA. One respondent that represents 4% said he does it all the time. 30% never do it while the remaining 18% do it only if a client demands. Below is table 4.2 and figure 4.2 which show the statistic of responders that practise LCCA at their places of work:

**Table 4.2:** Application frequency.

| Application of LCCA | Number | Percentage |
|---|---|---|
| All the time | 1 | 4% |
| If a client demands | 5 | 18% |
| Never | 8 | 30% |
| Partially | 13 | 48% |
| Total | 27 | 100% |

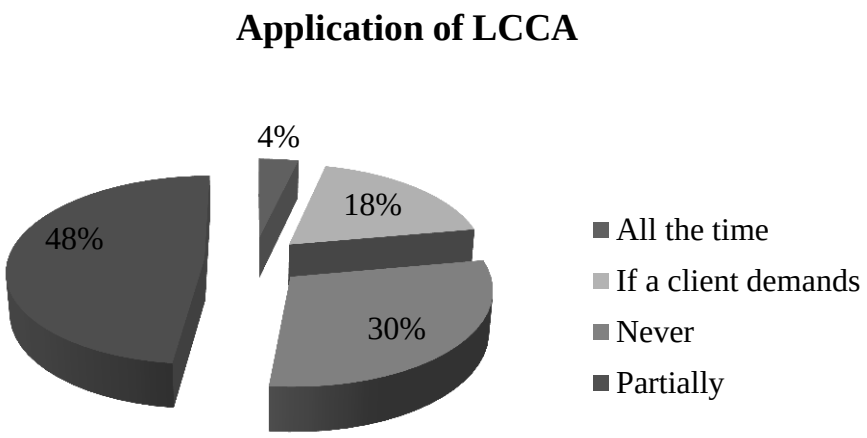


**Figure 4.2:** Application frequency (n=27).

Life Cycle Cost Analysis requires a good understanding of the concept and a lot of data and information about a building and its components in order to be performed fully as seen in the literature review. As will be restated in the reasons for its limited use in Uganda, it is difficult to have all this. This is the reason why most professionals in Uganda either do not perform LCCA or perform it partially.

However, there are number of other methods and technics that are used by building professionals in Uganda for decision making and selection between different projects and their different components, materials and systems. These technics are also applied by professionals abroad. They include the following:

- Aesthetics of the building
- Durability of materials, components and systems
- Initial costs and capital investment
- Consultations and experience from past projects
- Research and market trends
- Post occupancy evaluation studies
- Payback period
- Cost data compiled by company

- Analysis of current costs at the time of design against alternatives provided by suppliers.
- Working with and consulting other specialists such as mechanical and electrical consults.

It should be noted that a number of the above mentioned methods are part of the broader LCCA method thus the reason for partial application of LCCA by Ugandan professionals.

### 4.2 Considerations for Application of LCCA

Information and data about building components to aid in the application of LCCA in Uganda can be obtained from;

- Building materials catalogues;
- Manufacturer and supplier manuals
- Economic trends in terms of interest rates and material prices;
- Past experiences and cost data compiled within a company office.

These sources are similar to those used by professionals in the developed countries. In developing countries however, there exist extra sources such as websites were historical cost data can be extracted. Moreover, there are forecasting models that can also been used which is not the case in Uganda. Uganda does not have any cost databases where different companies can provide information on some of the projects they have done in the past. This is only possible at a companies' internal level. Government agencies, universities, private sector, manufacturers, producers & suppliers, the internet, design codes & standards and exposes & gatherings are some of the major places mentions where the information can be found. However, 84% of the respondents said that the information is sometimes accurate while only 4% said that it is accurate all the time. This therefore gives doubt in the effectiveness and reliability of a LCCA result when such data is used. Most respondents also observed that it is not easy for one to access this information all the time.

### 4.3 Limitations and Difficulties of Applying LCCA in Uganda

Most of the clientele in Uganda do not demand for LCCA on their projects because; it is too costly, it is too time consuming, the have never heard of it, they prefer other methods and many of them are only interested in the short term benefits. However, the respondents noted that the main reason clients do not demand for LCCA is that they are not aware of its benefits. And despite that fact that most professionals indicated that they inform their clients about LCCA, clients have not yet taken it up as part of their project pre-requisites. This is also a similar challenge in developed countries whereby clients are not very aware of the benefits of LCCA thus not considering it a prior in their demands for building services.

Although professionals believe it is very necessary to perform LCCA, Uganda does not have any known guide, framework or checklist for the application of LCCA. This can partly explain why LCCA has not been taken up in Uganda since professionals lack any basis for the process.

Lack of reliable sources of information and data for LCCA is another limitation to the practise. And available information is also not always easily accessible by the professionals as indicated in the survey.

When asked what they think was lacking for professionals to carryout LCCA in Uganda, figure 4.3 give a percentage of each of the reasons why;


**Figure 4.3:** What is lacking for professionals (n=27).

Majority of them said it was literacy of both the clients and themselves and their fellow professionals of LCCA that is the main reason why it is not being practised in Uganda. Other reasons included; the lack of information and data and accurate one too. Few started that due to a lack of a single source of information and data it was difficult to perform LCCA in Uganda.

One of the responders pointed out that there is also a limited range of materials available in Uganda. Since LCCA's main objective is to assist in decision making between choices, it would not be very helpful in a situation where similar materials are being used in the different alternatives. But in case these alternatives vary considerably in other aspects then the need for LCCA would arise.

Until it is proven to clients and professionals that LCCA affects the commercial viability of a project, it will be difficult to have this embraced by professionals. Therefore, as long as professionals and clients understand the benefits and how to carryout LCCA, then it will surely be taken up.

### 4.4 Conclusion

Life Cycle Cost Analysis is still a very new an unexplored technique of economic evaluation for the construction sector. Despite that fact that most professionals are aware of its existence and benefits, it is not being practise in Uganda. Those who attempt to apply it do it partially because they lack the appropriate tools for its performance. Ignorance by both professionals and clients is another factor.

However, majority of the professionals seem to understand and know the benefits and need for the practice of LCCA in Uganda. And this gives hope that it will be taken on in a few years to come. With the changing trends in the world where value for money is becoming the order of the day, techniques such as LCCA are being sort out. This should also be the case for Uganda that is still a developing country and has been hit by economic hardships in the past.

Other economic evaluation techniques are already being used in Uganda that are also used by professionals in the developed world. Resources for LCCA in Uganda are limited when compared to Europe and America. For example Uganda does not have any form of combined data bases where records of past projects are kept for future use. Yet in Europe and America companies offer information to be kept and used in a

general data bank thus making it easy to find information for LCCA. The culture of keeping such records it not yet strong in Uganda.

Despite all these challenges and limitations, it is possible to carry out LCCA in Uganda with the available tools, data and information as will be proposed in the next chapter.

# 5. PROPOSED CHECKLIST FOR BUILDING LIFE CYCLE COST ANALYSIS IN UGANDA

## 5.1 Proposed Procedure

### 5.1.1 Procedure

Below are proposed steps to be followed while performing Building Life Cycle Cost Analysis in Uganda:

a) Identify what project alternatives are available (these may also be building systems, materials, shapes, sizes etc)

b) Give a brief description of each alternative and the reasons why it is a project option for possible execution;

c) State and explain the assumption made for the LCCA;

d) Determine the following to be used in the calculation;

   i. Method of LCC, for example PV or EAC methods and respective discounting formulas;

   ii. Length of study period;

   iii. Discount rate;

   iv. Cost categories and all costs considered under each.

e) Determine and Estimate all costs to be included at today's rates;

f) Apply the costs into appropriate discounting formula and obtain output value;

g) Aggregate the output values together for each alternative and

h) Compare the results for each alternative and make a decision.

### 5.1.2 Stages

Therefore 3 main stages are proposed for the execution of LCCA in Uganda;

1. Planning stage;

This stage should include steps a, b, c and d of the proposed procedure above. It is the most crucial stage of the analysis. Here the available project alternatives should be identified and brief descriptions about each mentioned including why they are considered possible options for execution. Assumption for the analysis are also made and stated, and influential factors that can have a huge impact on the outcome of the LCCA are determined. These include; the method of LCC to be used, the length of the study period, the discount rate to be used and finally the cost elements to be considered for each cost category.

2. Application stage;

Here steps e, f & g of the proposed procedure are included. It involves the determination and estimation of cost values for each element. This can be done in the following ways;

- Use of historical data. Here the professional would use data from previous projects that may have been similar in nature, size, materials, design, function/use patterns, operational characteristics or other factors that may be deemed fit.
- Engineering method. This involves the direct estimation of a particular component. Prices and cost of these can be got directly from the market, traders, supplies & manufacturers, internet and other sources. This technique is similar to quantity surveying.

These values should then be applied into the respective discounting formulas to obtain an equivalent value at a given time. Aggregation for each category should then be made and a total sum of all categories obtained for each project alternative.

At this stage it is important to consider the uncertainities involved in the cost estimations made. İt is therefore appropriate to carryout sensitivity analysis or break even analysis so that the decisions that will be made later will have taken risk factors into consideration.

3. Comparison and Decision stage.

At this stage step h is executed. This involves the comparison of the outcome of all the computations made. It is when the different alternatives and compared to obtain the best suitable option. Each year, each cost category and each alternative can be compared. After this comparison, a decision should be made on which option is the most suitable for execution.

### 5.1.3 Proposed tables

Tables have been proposed that can be created in excel or a suitable computer programme to easy the ability to apply the formulas to the different cost elements and also to make comparison easy. Refer to figure 5.1 as a sample table:

| COST ITEM | Discounting formula | Interest rate | 1yr | 2yr | 3……n yrs | Aggregated value |
|---|---|---|---|---|---|---|
| **Acquisition costs** | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Sub-total | | | | | | |
| **Construction costs** | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Sub-total | | | | | | |
| **Operation cost** | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Sub-total | | | | | | |
| **Maintenance and Repair Costs** | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Sub-total | | | | | | |
| **Replacement Cost** | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Sub-total | | | | | | |
| **Renovation Costs** | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Sub-total | | | | | | |
| **Salvage value** | | | | | | |
| | | | | | | |
| | | | | | | |
| Sub-total | | | | | | |
| | | | | | | |
| | | | | | | |
| TOTAL | | | | | | |

**Figure 5.1:** Proposed application table.

Proposed in the table is a column for cost items, for discounting formula, for interest rate used, for each year period considered and finally for the aggregated sum of each

cost item. It is proposed that the rows should contain each cost category; Acquisition costs, Construction costs, Operation costs, Maintenance and Repair costs, Replacement costs, Renovation cost and a Salvage value. Under each of these categories will be specific cost items. Sub-totals of each category should also be made to enable comparison at this level. A final raw should have the totals of each year and also a combination of all the years and all cost categories. The above table should be filled for each project alternative separately where the respective data will be filled.

A second table is proposed to combine the data for each of the respective project alternatives into a summary for easy comparison. Refer to figure 5.2 below:

| | Option1 | Option 2 | Option 3 | Option …n |
|---|---|---|---|---|
| Acquisition costs | | | | |
| Construction costs | | | | |
| Operation cost | | | | |
| Maintenance and Repair Costs | | | | |
| Replacement Cost | | | | |
| Renovation Costs | | | | |
| Salvage value | | | | |
| | | | | |
| TOTAL | | | | |

**Figure 5.2:** Proposed summary table.

With proposed table in figure 5.2 above, each of the cost categories for each option can be compared by viewing them side by side. This will enable the decision maker make the best decision after a thorough comparison.

It should be noted however that the salvage value will be recorded as a negative. This is because it is not a cost but rather can be categorised as an income. It should therefore be subtracted from all other costs.

## 5.2 Critical Areas to Note that would have a great Impact on the Outcome of the LCC Analysis

### 5.2.1 Choosing method of LCC to apply

When choosing the method of LCC to apply, the professional should be sure of whether the alternatives available share the same number of life cycle years or are different. In case they have different lives, then Equivalent Annual Cost method must be applied. In this method, all costs will be discounted into an average annual value

before they are aggregated. And in case the project alternatives share the same life cycle years, the Present Value method should be used. With this method all costs are discounted to today's equivalent value and then aggregated to get the total cost.

### 5.2.2 Choosing discount rate

Discount rate select will have an immerse impact on the LCCA outcome. Literature reviews has still not come up with a systematic ways of determining which rate to use. Whether real or nominal or what factors to consider. In 2011-12 Uganda experience high inflation levels of up to 30% across all products. This could be an indicator of the need to use a nominal rate. However, in situations where the inflation is rather stable it is advisable to use a real rate thus not considering the effects of inflation. But whichever rate is chosen, different firms will have different considerations for the rate they pick. The following can help professionals in Uganda determine what exact value to pick;

- Borrowing rates set by the different commercial banks and other lending institutions,
- A rate that is charged on the companies/ clients current loans or that rate a client expects to pay for the use of borrowed funds.

Whichever rate is finally chosen, it must be the same rate applied to each cost element and for each project alternative to eliminate errors of inconsistency.

### 5.2.3 Choosing the length of study period

The length of study period is yet another fact that can greatly influence the outcome of a LCCA. Different organisations and clients choose different study periods for various reasons. However, in Uganda, the following are proposed as guides or indicators for choosing a suitable study period;

- The time required to pay back a loan/ debt. (if money for the project was borrowed)
- The time when the client wishes to have achieve the main objectives for the project executed.
- It should not be too long considering the uncertainties in the economy and political atmosphere.

- The life time of the project with the shortest life cycle.

### 5.2.4 Cost categories

The following main cost elements are proposed to be included under each of the proposed cost categories:

**Acquisition costs:**

- Land acquisition
- Site investigations
- Legal fees
- Indirect costs
- Design services
- Tendering process costs
- Equipement costs

**Construction costs**

- Earth works
- Substructure
- Super structure
- Walls, windows, doors & vents
- Roofing
- Finishing
- Site improvement
- Equipment & technology installations
- Construction management services
- Legal fees & permits
- Administrative
- Commissioning costs
- Contingency

**Operational costs**

- Facility management
- Insurance
- Operational Taxes & legal fees
- Electricity bills
- Water and sewerage bills
- Garbage disposal
- Security
- others

**Maintenance and repair costs**

- Site utilities and improvements
- Substructure
- Super structure
- Walls, windows, doors & vents
- Roofing system
- Plumbing fixtures
- Electrical systems
- Floor and ceiling
- Finishes
- Equipment
- Fire protection systems
- Other

**Replacement costs**

- Site utilities

- Super structure components
- Walls, windows, doors & vents
- Roofing system
- Plumbing fixtures
- Electrical systems
- Floor and ceiling
- Finishes
- Equipment
- Fire protection systems
- others

**Rennovation costs**

- Site utilities
- Super structure
- Roofing system
- Plumbing system
- Electrical systems
- Floor and ceiling
- Finishes
- Equipment
- Fire protection systems
- Others

**Salvage value**

- Site utilities
- Super structure
- Roofing system

- Plumbing system
- Electrical systems
- Floor and ceiling
- Finishes
- Equipment
- Fire protection systems
- Others

It should be not that the Building LCC analysis should not be limited to the above cost elements. Extra elements or adjustments can be made as seen fit by the professional during the planning stage.

# 6. CONCLUSION AND RECOMMENDATIONS

## 6.1 General

This research has explored the application of LCCA in the construction industry through a study of various literatures on the topic around the world. Then through questionnaire forms (refer to Appendix B) distributed among Ugandan construction professionals to obtain their view on the topic and compare with what is written in the literatures. Finally a checklist was proposed for carrying out Building Life Cycle Cost Management in Uganda.

Referring to chapters 2 and 4, difficulties and limitations to the practise of LCCA in the construction industry have been mentioned and discussed at length. However advantages and benefits have also been noted. Requirements for LCCA have also been well documented and their relevant application explained. Steps, stages and procedures for carrying out LCCA were expounded upon at great length in the literature review. All this led to the proposal of a checklist for LCCA in Uganda.

There is a lot of literature documenting how LCCA can be applied but a few examples illustrating how it has been successfully applied and its outcomes. This, however, could be because LCC calculations and corresponding cost models and cost data are commercially sensitive. Nevertheless, more effort has to be put on demonstrating how LCCA relates with other evaluation techniques like Life Cycle Assessments or benefit-cost studies.

As state in the literature review in chapter 2, the results of LCCA applications are only as accurate and reliable as the data and information that are used. Therefore data and information collected are the back born of a successful LCCA. Uganda, as noted in chapter 4, faces a huge challenge of having accurate, reliable and accessible data since this has a direct impact on the success of a LCCA.

However, many more challenges are and will be faced by professional who attempt to apply LCCA in Uganda. But due to the greater advantages and benefits the

application brings along, it is worth going through all the effort to perform LCCA in Uganda.

### 6.2 Why LCCA should be taken up in Uganda

It has been mentioned in chapter 4 during the analysis of the questionnaire forms that LCCA is not fully practised by most professionals in Uganda. But from the literature review and views from professionals practising in Uganda, there are a number of reasons why professional and clients should embrace and start applying LCCA;

- It is important to practise LCCA in Uganda in order to evaluate all costs that arise from owning, operating, maintaining and ultimately disposing of a project. LCCA is useful for the assessment of building design options that suit a requisite level of building performance (including user comfort, safety, observance of building codes and engineering standards, system reliability and aesthetic considerations), but which may have varying initial costs, differing operating, maintenance and repair (OM&R) costs and possibly different lives.
- The maintenance culture in Uganda is not strong. People are keen on getting the initial building cost which is high and do not want to hear about more costs. Taking up LCCA application will therefore create a sense of awareness of the need to have all costs considered in the early stages since that will lead to a less expensive option in the long run. A high construction cost may in the long run lead to a less expensive life cycle cost if LCCA is practised.
- It should because clients in Uganda like everywhere else deserve the best product for their investment. Life Cycle Cost Analysis helps to develop a good product and promotes and leads to sustainability, environmentally friendly and responsible design practises.
- It will add value to the project and it is also and international best practise thus raising the quality of the Ugandan construction industry.
- The trend in the world is toward sustainable development. And LCCA can be used to create sustainable projects in terms of economics. Therefore professionals will have no choice but to get in line or else they will become irrelevant in today's construction world.

### 6.3 Recommendations for LCCA to be taken on in Uganda

- More exposure and sensitisation through trainings and seminars where the importance of Life cycle costs is illustrated. This will create awareness and also inform the professionals and clients of the benefits of this practise.
- The concept has to first be introduce in all Higher Education Institutes of learning and then to extend the programmes to professionals already working. It should be incorporated into the curriculum of university students.
- The professionals should make the clients aware of the potential benefits of LCCA. Most clients are not aware that design options that increase their capital outlay may significantly reduce their future operating costs. The clients should therefore be made aware of the need to appraise running costs at the early stages of design options.
- Professionals, individually or in their respective firms should volunteer to collect accurate information and data from their colleagues or from the building industry and be able to share such information and data. This data can then be used in the application of LCCA thus removing the barrier of lack of reliable information.
- Professional bodies should encourage such services from members to clients and collect and harmonise information into a data bank that may be accessed by professional members. During CPDs (Continuous Professional Development seminars), members should be encouraged to present and discuss such information and data for the development of LCCA to potential clients.
- Setting up of systems to investigate and publish performance of various building materials, technologies, configurations etc. This may be taken up at national (Uganda) or regional (East Africa) level. This means government would have to come in to enforce this as a policy.
- LCCA should be made a prerequisite by government authorities in charge of building development, and proof of its utilisation should be presented to plan approval authorities when building plans are submitted.

### 6.4 Recommendations for Further Research

This thesis has been the tip of the iceberg for future research on the topic of Life Cycle Cost Analysis and Management for Uganda in particular. It should act as an opening to deeper and newer areas within this topic in Uganda. However, throughout the literature review, it is clear that more research should be done at a global level to improve the effectiveness of LCCA for a specific aim. Further research would also increase on the number of clients and professionals that apply LCCA. It has been noted in the literature review that one of the reasons why LCCA is not widely applied is the uncertainty by clients and professionals of some of the inputs required. Below are a few areas recommended for further research that would bring confidence to the would-be practitioner and thus more application of LCCA:

- More research to come up with firm guidelines for choosing the best interest rate to apply during LCCA;
- The relationship between building environment and sustainability issues and their assessment, and Life Cycle Cost Analysis and how the two can be combined;
- How LCCA relates to other methods of building economic evaluation and how a combined application can be done;
- More research dedicated to publishing successful applications of LCCA in the construction industry;
- The accuracy and reliability of building data and information for LCCA in Uganda;
- Research on life span of building materials, components and systems used in Uganda.

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**APPENDICES**

**APPENDIX A:** Questionnaire brief
**APPENDIX B:** Questionnaire form
**APPENDIX C:** Location of Uganda on the African continent
**APPENDIX D:** Life Cycle Cost Categories (for State of Alaska - Department of Education & Early Development Alaska School Facilities
**APPENDIX E:** ISO 15686-5 (ISO, 2006) list of cost variables required

**APPENDIX A**

Questionnaire Brief

# ISTANBUL TECHNICAL UNIVERSITY

## THESIS RESEARH

## MSc. PROJECT & CONSTRUCTION MANAGEMENT

Student Name**:** **Julius HAKIZIMANA**
Student ID**:** **5024111417**
Supervisor**:** **Prof. Atilla Dikbaş**

Topic:

**BUILDING LIFE CYCLE COST MANAGEMENT.**

Working Title:

**DEVELOPING A CHECKLIST FOR BUILDING LIFE CYCLE COST ANALYSIS IN UGANDA.**

**BRIEF**

Generally, a lot of focus has been place on the need to minimized production/ construction costs of a building forgetting about the impact of other costs and the decisions made in the various phases on the general building life cycle cost. Other costs include; initial land acquisition costs, maintenance and repairs, renovations, design costs to mention but a few. Decisions may include what kind of building systems, materials, shape, and many more that could significantly affect the long term cost of the building. And yet, minimising the cost of construction does not automatically lead to a reduction on the total life cycle cost. On the contrary, a higher construction cost could lead to a reduced LCC provided other long term costs are put into consideration.

Today, more and more focus is being turned to LCC management and not just single phases of the building's lives. This means that a lot of data, records and information about a building, its materials and systems have to be gathered for one to make a proper LCC analysis. A number of challenges have already been documented and research done in this area.

The purpose of this study is to review some of the research that has already been done into order to find out what information and how it is used by building

professionals today to carry out LCC analysis. Focus will then been drawn to the situation in Uganda. Uganda is a developing country located in East Africa that lies under the equator.

Questionnaires will be used to find out first, whether LCC Analysis is performed in Uganda or not. Then information about how LCC analysis is done and what sources of information are available for that in Uganda will be collected and a comparison made with what is being done in the developed world and also in the current literature on LCC analysis. In addition, information on what the challenges of doing a LCC Analysis in Uganda or why it may not be being practised will be gathered. This will be done with the sole purpose of coming up with a Framework/ guide and/ or Tools for building LCC analysis in Uganda.

**AIM:**

- To develop a Checklist for Building Life Cycle Cost Analysis in Uganda.

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**APPENDIX B**

Questıonaıre form

# ISTANBUL TECHNICAL UNIVERSITY

## (INSTITUTE OF SCIENCE & TECHNOLOGY)

## M.Sc. THESIS QUESTIONNAIRE FORM

Program**:** **M.Sc. PROJECT & CONSTRUCTION MANAGEMENT**

Student Name**:** **Julius HAKIZIMANA**

Student ID**:** **5024111417**

Supervisor**:** **Prof. Atilla Dikbaş**

Thesis Topic:

**BUILDING LIFE CYCLE COST MANAGEMENT**

Working Title:

**PROPOSED A CHECKLIST FOR BUILDING LIFE CYCLE COST ANALYSIS IN UGANDA.**

# QUESTIONNAIRE FORM:

Please respond to the following questions by either ticking the appropriate box (if the form is printed or highlighting and saving your answer to ***bold Italics format***) or by writing your answer in the space provided (***bold Italics format)***.

For example;

Qn: What is your name?

- ☐ John
- ☐ ***Julius***
- ☐ Jane
- ☐ James

For the question above, Julius is selected as the answer.

Please note: All information provided will be treated in the strictest of confidence.

**SECTION 1:**

1. What is your academic background?
   - ☐ Architectural
   - ☐ Engineering
   - ☐ Quantity Survey/ Building Economics
   - ☐ Business (Now contractor)
   - ☐ Other (state) …….
2. What does your company or institution do?
   - ☐ Architectural works
   - ☐ Engineering works
   - ☐ Contracting works
   - ☐ Quantity surveying
   - ☐ Government department or NGO (explain)
   - ☐ Other (state)……
3. How long have you been practising in the Built Environment?
   - ☐ Less than 2 years
   - ☐ 2-5 years
   - ☐ 5- 10 years
   - ☐ 10-20 years
   - ☐ More than 20 years
4. What kind of projects do you normally engage in
   - ☐ Residential
   - ☐ Commercial (hotels, shopping malls, restaurants etc)
   - ☐ Office
   - ☐ Public (schools, hospitals, government)
   - ☐ Industrial
   - ☐ Other (state)……
5. What is the level of education of most of your clients?
   - ☐ Illiterate (did not attain any education)
   - ☐ Semi- literate (attend primary school)
   - ☐ Literate (attended secondary school)
   - ☐ Very literate (attended at a higher institution of learning)
   - ☐ Other (state)……

6. How many projects have you/ firm or institution actively participated in?
   - ☐ Less than 10
   - ☐ 10 - 20
   - ☐ 20 - 50
   - ☐ 50 - 100
   - ☐ More than 100

**SECTION 2:**

7. Are you familiar with the concept of Life Cycle Cost Analysis and Management?
   - ☐ Yes
   - ☐ No
   - ☐ Never heard of it
   - ☐ Heard of it but never applied it
   - ☐ Other (state)……

8. Briefly state what it means and/ or involves to you as an individual or firm?

9. Are you (or firm/ institution) aware of the benefits of Life Cycle Cost Analysis and Management?
   - ☐ Yes
   - ☐ No
   - ☐ Other (state)……

10. Do your colleagues know the benefits of Life Cycle Cost Analysis and Management?
    - ☐ Yes
    - ☐ No
    - ☐ Not sure
    - ☐ Other (state)……

11. Do you do Life Cycle Cost Analysis for your or firm/ institution's projects?

- ☐ All the time
- ☐ If a client demands
- ☐ Never
- ☐ Partially
- ☐ Other (state)……

12. Does your firm/ institution have someone or department specifically responsible for Life Cycle Cost Analysis calculations?

- ☐ Yes
- ☐ No
- ☐ We are thinking about it
- ☐ Other (state)……

13. Do your firm/ institution's clients ever require you to make a Life Cycle Cost Analysis?

- ☐ All the time
- ☐ Some times
- ☐ No
- ☐ Other (state)……

14. Is the concept of Life Cycle Cost Analysis being taught in the Built Environment departments at universities in Uganda (Is it part of curriculum)?

- ☐ All the time
- ☐ Some times
- ☐ No
- ☐ I don't know
- ☐ Other (state)……

15. What evaluation methods do you use to select between choices of; building materials, systems, suitable choice of projects for clients etc

- ☐ Life Cycle Cost Analysis
- ☐ Others (state)……
- ☐ ……
- ☐ ……
- ☐ ……
- ☐ ……

16. What sources of information and data are available to aid one in a building (components or whole systems or projects) selection decision of any kind in Uganda?

- ☐ Building Material Catalogues
- ☐ Manufacturer and Supplier manuals
- ☐ Economic trends (e.g. interest rates)…
- ☐ Past experiences
- ☐ Other (state)……
  ……..……

17. Where can one access this information/ data?

- ☐ Government Agencies e.g.……
- ☐ Universities (state) e.g.…….
- ☐ NGOs e.g…….
- ☐ Private Sector e.g…….
- ☐ Producer and Suppliers e.g.……
- ☐ Other (state)……..

18. Is the information accurate?

- ☐ All the time
- ☐ Some times
- ☐ No
- ☐ I don't know
- ☐ Other (state)……

19. Is the information easily accessible?

- ☐ All the time
- ☐ Some times
- ☐ No
- ☐ I don't know
- ☐ Other (state)……

20. Why don't clients require you to perform a building Life Cycle Cost Analysis?

- ☐ It is too costly
- ☐ It is too time consuming
- ☐ They do not know the benefits
- ☐ They have never heard of it

☐ Other (state) …….……

21. Have you (firm/ institution) ever informed clients about Life Cycle Cost Analysis?
    - ☐ All the time
    - ☐ Some times
    - ☐ No
    - ☐ Other (state)……

22. If you answered negative above, why not?
    - ☐ I am not familiar with the concept
    - ☐ It is too costly for them
    - ☐ It is too time consuming
    - ☐ Don't think it is necessary
    - ☐ Don't have the necessary information to perform it
    - ☐ Other (state)……

23. Is there a framework, model or guide for Life Cycle Analysis in Uganda today?
    - ☐ Yes
    - ☐ No
    - ☐ I don't know
    - ☐ Other (state)……

24. Do you think it is necessary to practise Life Cycle Cost Analysis in Uganda today?
    - Yes
    - No
    - I don't know
    - Other (state)……

25. Why? (Explain response above)

26. What do you think is lacking for professionals to carryout Life Cycle Cost Analysis?

    - ☐ Information and data
    - ☐ Accurate information and data
    - ☐ Ignorance by professionals on Life Cycle Cost Management
    - ☐ Ignorance by client on Life Cycle Cost Management
    - ☐ I don't know
    - ☐ Other (state)……

27. Briefly explain whether you think Life Cycle Cost Analysis should or will be taken up among both professionals and clients.

28. What do you recommend to be done so that Life Cycle Cost Analysis is taken up among both professionals and clients?

29. Please mention any other information that you think may help my study in order to develop and model/ framework/ guideline for Life Cycle Cost Analysis in Uganda.

***Thank you very much for your co-operation.***

## APPENDIX C

**Figure A.1** Location of Uganda on the African continent

**APPENDIX D**
Life Cycle Cost Categories (for State of Alaska - Department of Education & Early Development Alaska School Facilities

**A. Initial Expenses**

- **Initial Investment Cost** (one time start-up costs)

  Construction Management

  Land Acquisition

  Site Investigation

  Design Services

  Construction

  Equipment

  Technology

  Indirect/Administration

  Art

  Contingency

**B. Future Expenses**

- **Operation Cost** (annual costs)

  Heating Fuel

  Electricity

  Water and Sewer

  Garbage Disposal

  Custodial

  Grounds

  Lease

  Insurance

- **Maintenance and Repair Cost** (scheduled & unscheduled upkeep costs)

  Site Improvements

  Site Utilities

  Foundation/Substructure

  Superstructure

Exterior Wall Systems

Exterior Windows

Exterior Doors

Roof Systems

Interior Partitions

Interior Doors

Interior Floor Finishes

Interior Wall Finishes

Interior Ceiling Finishes

Interior Specialties

Conveyance Systems

Plumbing Piping

Plumbing Fixtures

Fire Protection Systems

HVAC Distribution

HVAC Equipment

HVAC Controls

Electrical Service/Generation

Electrical Distribution

Electrical Lighting

Special Electrical Systems

Equipment & Furnishings

- **Replacement Cost** (scheduled replacement of building systems or components)

  Site Improvements

  Site Utilities

  Foundation/Substructure

  Superstructure

  Exterior Wall Systems

  Exterior Windows

Exterior Doors

Roof Systems

Interior Partitions

Interior Doors

Interior Floor Finishes

Interior Wall Finishes

Interior Ceiling Finishes

Interior Specialties

Conveyance Systems

Plumbing Piping

Plumbing Fixtures

Fire Protection Systems

HVAC Distribution

HVAC Equipment

HVAC Controls

Electrical Service/Generation

Electrical Distribution

Electrical Lighting

Special Electrical Systems

Equipment & Furnishings

- **Residual Value** (value of facility at end of study period)

  Site Improvements

  Site Utilities

  Foundation/Substructure

  Superstructure

  Exterior Wall Systems

  Exterior Windows

  Exterior Doors

  Roof Systems

Interior Partitions

Interior Doors

Interior Floor Finishes

Interior Wall Finishes

Interior Ceiling Finishes

Interior Specialties

Conveyance Systems

Plumbing Piping

Plumbing Fixtures

Fire Protection Systems

HVAC Distribution

HVAC Equipment

HVAC Controls

Electrical Service/Generation

Electrical Distribution

Electrical Lighting

Special Electrical Systems

Equipment & Furnishings

**APPENDIX E:**

ISO 15686-5 (ISO, 2006) list of cost variables required

**a) Acquisition costs**

Acquisition costs include;

- Site costs;
- Temporary works
- Design/ engineering costs;
- Regulatory/ planning costs;
- Construction and earthworks;
- Commissioning costs/ fees
- In-house administration

**b) Maintenance, operation and management costs**

Maintenance, operation and management are necessary for ensuring that a facility functions and operates properly and as planned throughout its life cycle. The cost items considered in this phase are as follows:

- Rates (this is an operation cost);
- Insurance (this is an operation cost);
- Energy costs (this is an operation cost);
- Water and sewage costs;
- Facilities management (this is an operation/ management cost);
- Cleaning (this is an operation cost);
- Security (this is an operation cost);
- Annual regulatory costs (e.g. fire, access inspections) and regulatory maintenance costs (this is a maintenance cost);
- Maintenance (e.g. repairs, replacement, refurbishment);
- Revenue from ownership or use of the asset (e.g. rent, service charges etc)

Other costs to be considered in this phase include:

- Demolition;
- Cost of disposal;
- Unanticipated costs resulting from legislation introduced subsequent to completion of the constructed asset e.g. in relation to environmental, health and safety requirements or fiscal matters

Maintenance activities usually include inspection, monitoring, testing, condition surveys/ inspections, maintenance planning, repairing, refurbishing, and partial replacements. The following indirect impacts of maintenance works can also be taken into account:

- Down time (loss of function for period);
- The disruption of business activity;
- The non-availability of a building/structure;
- The cost effects of aesthetic condition;
- The maintenance strategy;
- External costs/saving data;
- Whether any other costs or savings will be made as part of the option appraisal process with this being identified in the LCC Analysis.

**c) Residual values/disposal costs**

A few alternatives are recommended in ISO 15686-5 (2006) for estimating residual value:

- "The prices for similar assets current on sale in the market;
- Book estimates of resale value available from the industry or government sources;
- Using accepted practise to assess asset values."

For estimating disposal costs, environmental legislation must be taken into account.

**d) Other cost variables**

Other cost variables to be considered in LCC are:

- Discount rate;
- Inflation;
- Taxes and subsidies;
- Utility costs including energy costs

The environmental cost variables are currently not considered in the ISO standard. Nevertheless, there have been attempts to incorporate eco-costs in LCC.

**CURRICULUM VITAE**

| | |
|---|---|
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