

**IMPACT OF SCOPE DEFINITION INDETERMINACY
ON IRON TRIANGLE PERFORMANCES IN PUBLIC
BUILDING CONSTRUCTION PROJECTS**

H.M.P.S.Herath

(189543L)

Master of Science in Construction Law and Dispute Resolution

Department of Building Economics

University of Moratuwa

Sri Lanka

June 2022

IMPACT OF SCOPE DEFINITION INDETERMINACY ON IRON TRIANGLE PERFORMANCES IN PUBLIC BUILDING CONSTRUCTION PROJECTS

H.M.P.S.Herath

189543L

Dissertation submitted in partial fulfilment of the requirements for the degree Master
of Science in Construction Law and Dispute Resolution

Department of Building Economics

University of Moratuwa

Sri Lanka

June 2022

DECLARATION

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Post graduate Degree in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Further, I acknowledge the intellectual contribution of my research supervisor Dr. (Mrs) Chandanie Hadiwattege for the successful completion of this research dissertation. I affirm that I will not make any publication from this research without the name of my research supervisor as contributing author unless otherwise I have obtained written consent from my supervisor.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works such as articles or books.

UOM Verified Signature

H.M.P.S.Herath.

30 / 06 / 2022

Date

The above candidate has carried out research for the Dissertation under my supervision.

UOM Verified Signature

Dr.(Mrs) Chandanie Hadiwattege.

30 / 06 / 2022

Date

Dissertation Supervisor

ABSTRACT

Public building projects are vital in the construction industry since they can provide a variety of public benefits and improve the efficiency of public utilities. The Iron Triangle is a crucial driver of public building projects, ensuring project success through proper management of the Iron Triangle's components. However, when it comes to the elements that have identified in this research, the scope is the most important factor to consider. As a result, analysing the impact of the Iron Triangle due to scope indeterminacy in public building projects is a critical performance metric for reducing negative impacts on the Iron Triangle and ensuring the efficacy of public building projects. Therefore, the study focuses on the assessing the above impact of scope indeterminacy on the performance Iron Triangle in public building projects. Case content analysis and descriptive statistics were used to analyse the empirical data acquired from expert interviews and a questionnaire survey.

The studies revealed twenty-seven causes for scope indeterminacy in public building projects, with twelve (12) of them being unique to public building projects. In addition to that, the study discovered 34 handling strategies for reducing the impact of scope indeterminacy. In the context of public building projects, eleven of the most severe causes of scope indeterminacy for Iron Triangle performance were discovered, with "Lack of Planning" and "Lack of Concentrate on Defining Scope" being the most severe causes of scope indeterminacy for Iron Triangle performance in public building projects.

Keywords: Public Building Projects, Scope Indeterminacy, Iron Triangle

DEDICATION

**I'd want to dedicate my work to my devoted
father who taught me the meaning of life and
esteemed instructors, who have never wavered
in their support, devotion, and
encouragement.**

ACKNOWLEDGEMENT

This research covers the dedication and ready assistance of many people and organisations who have contributed to the completion of this research in rich ways. Therefore, I take this opportunity to thank everyone.

It is my foremost duty to pay my gratitude to my supervisor Dr. (Mrs) Chandanie Hadiwattege for the great commitment, guidance, and encouragement given throughout the research. Further, I extend my gratitude to Plnr. (Mr) E.A.C Piyashantha DDG/RED UDA for providing the required details to carry out the research.

My sincere gratitude shall also be extended to Prof. (Mrs)Yasangika Sandanayake, Course Director/ Former Head of the Department of Building Economics, Ch. QS (Mr) Suranga Jayasena, Head of the Department of Building Economics, and, Mr. Waruna Vidyaadikariarachchi Programme Assistant and much other academic staff of the department for their immense guidance and support given throughout the research period and my academic years of the University.

Special thanks to all the expert interviewees and industry practitioners who gave me immense support to complete a successful data collection by sharing their valuable knowledge and experiences with me.

Finally, I sincerely thank my family members, and all my companions for sharing their experience and knowledge throughout the learning process

H.M.P.S Herath

June 2022

TABLE OF CONTENTS

LIST OF FIGURES	ix
LIST OF TABLES	x
LIST OF ABBREVIATIONS	xi
1. INTRODUCTION	CHAPTER 1
1.1 Background	1
1.2 Problem Statement	4
1.3 Aim of the research	5
1.4 Objectives of Research	5
1.5 Scope and Limitations.....	5
1.6 Research Methodology	5
1.6.1 Literature Review.....	5
1.6.2 Expert Interviews	6
1.7 Chapter Summary	6
2. LITERATURE REVIEW	CHAPTER 02.....
2.1 Introduction.....	7
2.2 What is ‘Scope’?	7
2.3 Scope in Construction Projects	8
2.4 Significance of the Defining Scope in the Construction Projects.....	9
2.5 What is “Scope Indeterminacy” in the Construction Context.....	10
2.6 Impact of project scope indeterminacy on the construction projects.....	11
2.7 Causes of project scope indeterminacy	11
2.8 Maintaining Performance of Iron Triangle in construction projects.....	15
2.9 Impact of Project Scope on Iron Triangle	18
2.10 Impact of Scope Changes on the Iron Triangle	20
2.11 Scope Management in Construction Projects	22

2.12 Scope Management Strategies to Manage Scope Changes in Construction Projects.....	24
2.13 Cost overruns, quality issues and delays in Public Construction Projects.....	25
2.14 Impact of scope Indeterminacy in public Construction projects.....	27
2.15 Public Building Projects	28
2.16 Defining Project Scope in Public Building Projects and Responsible Parties.	29
2.17 Chapter Summary	30
3. METHODOLOGY	
CHAPTER 03	31
3.1 Introduction.....	31
3.2 Research Design.....	31
3.2.1 Exploratory	31
3.2.2 Descriptive	32
3.2.3 Explanatory	32
3.2.4 Selected Design for this Research.....	32
3.3 Research Approach	33
3.3.1 Qualitative Approach	33
3.3.2 Quantitative Approach	34
3.3.3 Mixed Approach	34
3.4 Selected Approach for this Research	34
3.5 Research Strategies	35
3.5.1 Case Studies	35
3.5.2 Survey Strategy	35
3.5.3 Selection of Sampling	36
3.6 Qualitative Data Analysis Techniques – Case Content Analysis	36
3.7 Quantitative Data Analysis Techniques – Relative Important Index (RII).....	36

3.8 Research Process.....	38
3.9 Summary	39
4. DATA ANALYSIS	CHAPTER 04..... 40
4.1 Introduction.....	40
4.2 Phase I - Case Studies	40
4.2.1 Objectives of Case Studies.....	40
4.2.2 Background of the Cases	40
4.2.3 Respondents of Interviews.....	46
4.2.4 Findings of Case Studies.....	46
4.2.5 Causes for the indeterminacy of project scope	47
4.2.6 Management Strategies for reducing causes of project scope indeterminacy	57
4.3 Phase II – Questionnaire Survey.....	72
4.3.1 Objectives of Questionnaire Survey	72
4.3.2 Respondents of Questionnaire Survey	72
4.3.3 Findings of Questionnaire Survey	73
4.4 Additional Findings of the Research.....	76
4.4.1 Process of Project Scope implementation in Government Projects.....	76
4.5 Discussion	78
4.5.1 Causes of Scope Indeterminacy	78
4.5.2 Strategies to Minimise Causes of Scope Indeterminacy	79
4.5.3 Impact on Iron Triangle	79
5. CONCLUSIONS AND RECOMMENDATIONS	CHAPTER 05.....81
5.1 Introduction.....	81
5.2 Conclusion	81

5.2.1 Objective 1: Critically review the phenomena of indeterminacy of scope definition in the context of construction projects.....	81
5.2.2 Objective 2: Identify the causes behind the indeterminacy of project scope definition in Public Building Projects.....	81
5.2.3 Objective 3: Develop strategies to minimise the impact of indeterminacy of project scope definition on Iron Triangle Performance in public sector projects.	82
5.2.4 Objective 4: Appraise the impact of indeterminacy of project scope definition on Iron Triangle Performance in public sector projects	82
5.3 Recommendations.....	82
5.4 Limitations of the Study.....	84
5.5 Further Researches.....	84
References	85
ANNEX I - INTERVIEW GUIDELINE.....	118
ANNEX II - QUESTIONNAIRE	122

LIST OF FIGURES

Figure 2.1: Impact of Scope for the Iron Triangle.....	18
Figure2.2: Major components to be considered to reach customer satisfaction.....	19
Figure 2.3: Project Scope Management Framework; Source PMBok 2013.....	23
Figure 3.1: Research Process.....	38
Figure 4.1: Causes for Scope Indeterminacy.....	56
Figure 4.2: Management Strategies for reducing scope changes in Public Building Projects.....	71
Figure 4.3: Most Impacted Causes for Iron Triangle.....	76
Figure 4.4: Government project Implementation Process.....	77

LIST OF TABLES

Table 2.1: Causes for Changes in Scope.....	12-15
Table 2.2: Key Features of Iron Triangle.....	16
Table 2.3: Impact of Project Scope Changes.....	21
Table 2.4: Scope Management Strategies to Control Scope Changes.....	24
Table 4.1: Background of Case Studies.....	41
Table 4.2: Respondents of Interviews.....	46
Table 4.3: Causes for the indeterminacy of project scope.....	47
Table 4.4: Management Strategies for reducing Scope indeterminacy.....	57
Table 4.5: Respondents of Questionnaire Round.....	72
Table 4.6: Most Impacted Causes for Iron Triangle.....	73
Table 4.7: Compare and Contrast Literature Findings and Study Findings.....	79

LIST OF ABBREVIATIONS

CIA - Construction Industry Association

CIDA- Construction Industry Development Association

DAB - Dispute Adjudication Board

ER - Employer's Requirement

GDP – Gross Domestic Product

ICTAD- Institute for Construction Training and Development

NPA – National Procurement Agency

NPD- Department of National Planning

NPPIS- National Public Project Implementation System

PDRI - Project Definition Rating Index

PE - Procuring Entity

PMI - Project Management Institute

RDA – Road Development Authority

RII – Relative Importance Index

ROI – Return of Investment

SBD – Standard Bidding Document

SL – Sri Lanka

SPSS - Statistical Package for the Social Sciences

UDA – Urban Development Authority

1.1 Background

Definition of project scope is the approach whereby the work that is necessary to produce a building is defined and identified in adequate detail to facilitate project implementation an indeterminacy of scope definition could impact project outcomes (Gibson et al. 2006). Schwalbe (2014) mentioned that, in construction, the project process creates the product or service through all works involved in creating the same scope. The scope defines the boundaries of a project, and what will have been done or is not to be done which is called the Statement of work schedule or project initiation document for all work to follow during project implementation. If it is more accurate, the project scope is correct (Lieberman, 2001).

A successful definition of the scope of a project ensures smooth and successful implementation during the project execution (Chritamara et al., 2001; Gibson et al. 2006). However, scope indeterminacy is created in a project an authorised decision made by the client to change the design to expand or reduce. Inadequate project planning and scope definition indeterminacy frequently lead to project failures. Furthermore, carry on to major causes of exclusive changes are delays, variations, cost, and time overruns (Mirza et al., 2013; Lordsleem & Melhado 2014). Researchers have identified major barriers to project success as poor scope definition and improper control of those (Mirza et al., 2013). Thus, the indeterminacy of scope definition creates project stakeholders' dissatisfaction due to their expectations not being fulfilled (Cano & Lidón 2011).

The most common reasons for the scope definition indeterminacy in public projects are owner instructs to a modification to design due to financial constraints or government changes, project acceleration due to political influences, or owner instructs to change the locations due to land acquisition problems (Alsuliman, 2019). However, it directly involves adjusting the cost, budget, and other features or the timeline (Zawawi 2010). Hanna, et. al., (2002) explain that the result of modification of the original scope will affect the time, and cost of work, in a construction project.

Zawawi, (2010) shows that changes to the original project scope make the agreed contract amount and project duration. The Employer develops a project with his own and wider objectives such as the value for money, aesthetic view fit for the purpose, reasonable operation cost, and durability. (Latham,1994). Nayyar (1994) mentions that the indeterminacy of scope definition includes cost and time overruns in the original budget and the schedule of the project caused by the change in the originally contemplated scopes.

In addition to that, Chick (1999). showed that, in the project, the indeterminacy of scope definition occurs during the construction stage, which will affect the project cost and the possible effect on the project schedule. For most public projects due to the influence of politics early completion is a common fault (Fageha & Aibinu, 2014). Alsuliman, (2019) shows that considering the Public Building Construction projects their project duration exceeds more than 75% of the planned time compared with the original project duration. Further, Ndiokubwayo (2008) mentioned that, once a scope change is occurring in a contract the significance disrupts practically all stakeholders in numerous magnitudes. Therefore, the scope indeterminacy of a project often resulted in disagreements and dissatisfaction between the parties due to delayed progress, and difficulty, to manage an extra cost.

Alsuliman, (2019) identified that 112 factors affect scope changes in Saudi Arabian Public Building Construction projects. According to that, the factors during the awarding of tenders take a higher rank for the indeterminacy of scope definition. Assbeihat and Sweis (2015) showed the main causes of scope changes are mainly arising from the owner's internal environment, furthermore, the most important affecting factors are owner gives design modifications and extra work instructions. Noman et al. (2018) mention that the most frequent delay element in the construction projects of public sector in Saudi Arabia are lack of communication between the stakeholders, client financial difficulties to complete the project, and poor qualifications of the staff assigned.

Considering the above facts, to avoid these consequences accurate scope definition takes the most important part of a project. In addition to that, project cost, quality, and time management are the way of project life (Cho & Gibson, 2001). Mbachu and

Nkado (2007) explain that; to create and retain a satisfied client service provider in the construction industry must meet the opportunities and requirements of their clients in the delivery of projects. Overall, considering project budgeting, estimation, and financing can get a genuine image of the actual way, of project progress. Therefore, project cost management and proper attention to scope definition are very essential especially, for public projects. Any construction completion without adjustment to project scope, timeline, or budget is impossible especially considering the implementation of the public projects in Sri Lanka. Most products are never the same as the original plan (Manike 2015).

According to the Procurement Guideline in Sri Lanka, the priority given for public project implementation is to follow the competitive bidding system (Procurement Manual 2006. page 45). It would seem that, the Contractor with the lowest tender price wins the project. Urban resettlement housing programs for low-income people, middle-income housing programmed for government servants and other professionals in the industry, administrative complexes for state organizations, commercial buildings, infrastructure facilities, industrial facilities, hospitals, and public utilities are the priority projects for the year (Budget Estimate 2021 published by Ministry of Finance, Sri Lanka).

Furthermore, the National Planning Guideline Sri Lanka (2019) mentioned that the project implementation process is based on several factors including priority projects, financial capabilities, technical analysis with relevant approvals, project interrelationship, and link with different ministries according to the development plan, national requirements, or national budget. Ndiokubwayo (2008) mentioned that “it takes the most valuable part of a project to make a complete design at the beginning to reduce the scope definition indeterminacy” Therefore, there shall be an accepted mechanism to execute these changes.

Hence, the purpose of this research is to find out the most significant solutions to avoid the impacts on the Iron Triangle performances from the indeterminacy of scope definition in public building construction projects and develop strategies for successful project implementation and completion in the public sector constructions.

1.2 Problem Statement

Scope indeterminacy of a project often resulted in disagreements and dissatisfaction between the parties due to quality management, delayed progress, and difficulty to manage an extra cost as reported in the background of the study. All projects begin with the definition of needs, such as the needs of the client, the needs of the development organisation, the need of the project managers, programmers, architects, and more. These needs cannot be achieved within a reasonable time frame (Liberman,2001). Based on the delay of a project the Employer faced many difficulties such as loss of revenues, injury to his reputation, the extended cost for the Employer's administrative overhead and loss of profit for incurred cost. On the other hand, the Contractor plan to get entitlements from the Employer-based on variation and time extension of the project such as, overhead charges with profit and many contractual and extra-contractual claims with profit, and many other claims relevant to the particular case an agreement between the parties to the contract. Therefore, at the end of the day dissatisfaction between the Employer and the Contractor may occur. Kauffmann et al. (2002) mention that, the earned value method in quantifying change of scope subject to cost adjustments, overruns unnecessary delays low quality and dissatisfaction, and conflict among stakeholders are the ultimate significances of scope changes. Furthermore, it makes the most valuable part of a project to make a complete design at the beginning to reduce the scope definition indeterminacy (Ndiokubwayo,2008). Further, in the Sri Lankan construction industry especially for public projects frequently finished delays and over budget due to changes in the project scope (Manike 2015).

Further, many researches have been talking about the cost and time impact to the project scope changes in the public construction except the Iron Triangle impact based on the scope definition indeterminacy in public building projects (Alsuliman, 2019; Fageha & Aibinu, 2014; Perera & Sirimewan, 2021; Saindu et al, 2018). Hence, minimise the impact of indeterminacy of project scope definition effect for balancing cost, timeline and project scope and the quality of the overall project and it directly involves adjusting the Iron Triangle. Therefore, this research focuses on fulfilling the

industry need and literature gap under the topic of indeterminacy of scope definition on Iron Triangle performance in Public Building Construction Projects

1.3 Aim of the research

This research aims to investigate the impact of indeterminacy of scope definition on Iron Triangle performances in public building construction projects.

1.4 Objectives of Research

To achieve the aim of the study following objectives are formulated.

- Critically review the phenomena of indeterminacy of scope definition in the context of construction projects
- Identify the causes behind the indeterminacy of project scope definition in public building projects
- Develop strategies to minimise the impact of indeterminacy of project scope definition on Iron Triangle performance in public sector projects.
- Appraise the impact of indeterminacy of project scope definition on Iron Triangle Performance in public building projects

1.5 Scope and Limitations

This research is carried out to investigate the impact of indeterminacy of scope definition on Iron Triangle performances in public building construction projects in and this study is limited to public building projects in Sri Lanka.

1.6 Research Methodology

1.6.1 Literature Review

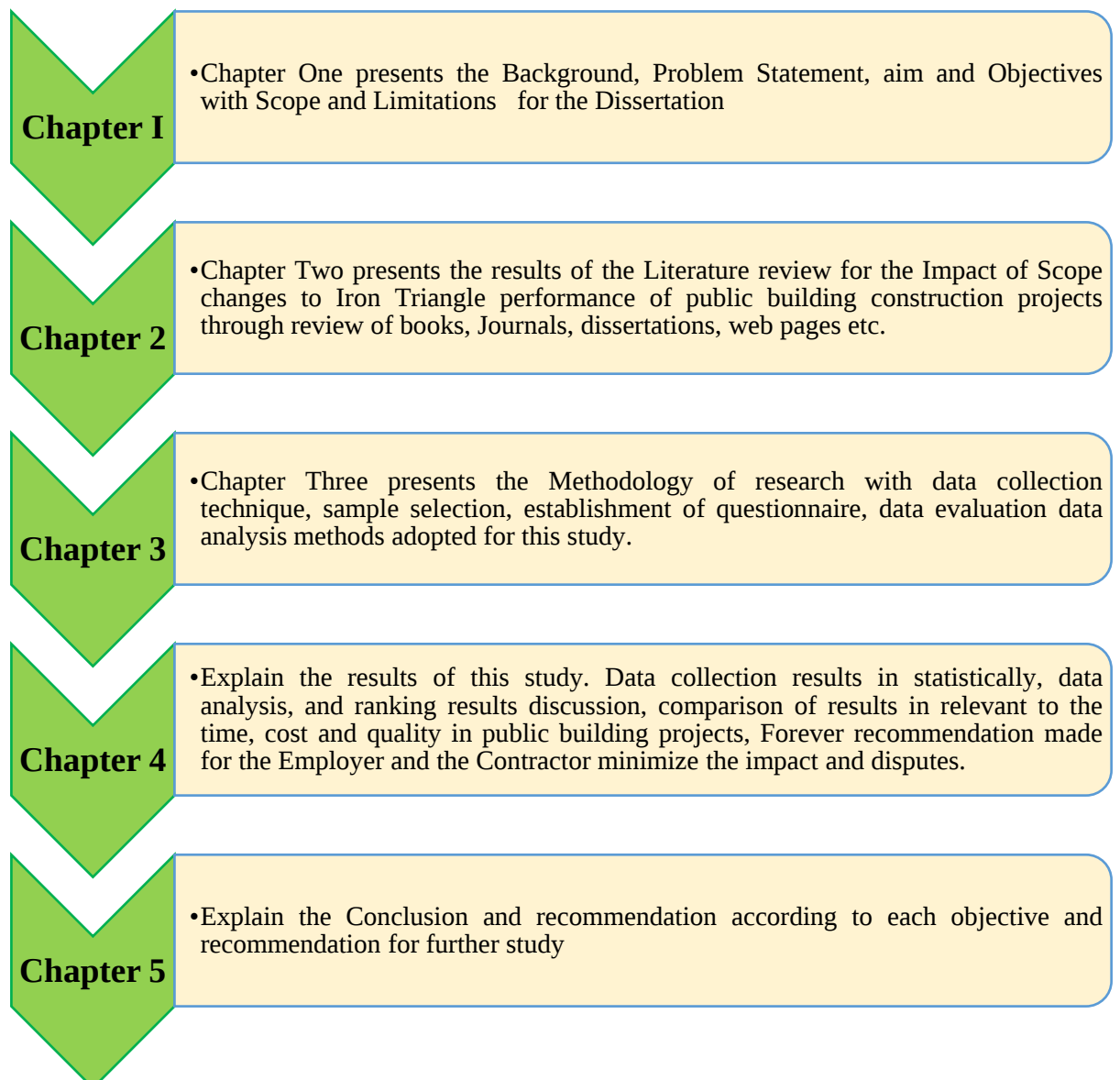
A comprehensive literature review was carried out by referring to journal papers, conference proceedings, Books, Dissertations, websites, magazine articles, and unpublished dissertations. etc.

Phenomena of indeterminacy of scope definition and the impact of indeterminacy of project scope definition on the Iron Triangle were mainly declared in the literature review.

1.6.2 Expert Interviews

Expert interviews were conducted with experts in government sector professionals, such as Architects, Quantity Surveyors, Engineers, Town Planners, in the construction industry and the Contractor professionals. before achieving further objectives identify reasons and propose suitable strategies to minimise scope changes based on the cases of disputes and the probable strategies to overcome the resultant impact on the project performance.

1.7 Chapter Summary



2.1 Introduction

The background and problem statement of the study area have been discussed in chapter one. As well as the aim and objectives of the study have been established in the same chapter. In the literature review, the major focus is to critically investigate the scope changes on the Iron Triangle performance in public construction projects and further identify the critical causes and recommendations to minimise the impact of scope changes on the Iron Triangle.

2.2 What is 'Scope'?

Defining the scope with the input of all stakeholders is a crucial task that must be completely implemented early in any production process (Fageha & Aibinu, 2013). However, different authors have defined the term "scope" in different ways (Narvaez, Mateo, & Fernandez, 2016). According to Gibson, Wang, Cho, & Pappas (2006), the aim of project scope is to provide enough details to define the work that needs to be done in order to prevent significant modifications that could negatively affect project performance. However, Fitsilis, Damasiotis, & O'Kane (2015) have similar ideas to the above statement on defining the scope and stated to determine the precise scope of work that must be completed during the project, the process of gathering the expectations and requirements of project stakeholders must be defined. Moreover, in order to manage a project scope effectively, it is required to identify the work that has to be done, the order in which it should be done, the working time allotted, the resources needed, and the project's cost (Derenskaya, 2018). Furthermore, according to the "Guide to the Project Management Body of Knowledge" (PMBOK® Guide, 2008), the term "scope" refers to the content of the product or the content of the entire project. Therefore, the term "scope" can be classified into two components; product scope and project scope (Mirza et al., 2013).

The sixth edition of the PMBOK Guide stated that a product is an artifact or a quantifiable product, which itself can be a final project or a component project (Usmani, 2021). However, the product scope can be defined as the characteristics or characteristics of the product itself (Denny, 2018). The above statement was supported by Mirza, Pourzolfaghar, and Shahnazari (2013) and stated that product scope is the

attributes and characteristics of deliverables in project creation. However, the project scope depends entirely on the product scope (Usmani, 2021). The work necessary to produce project deliverables is covered by the project scope (Mirza et al., 2013). Therefore, the scope of the project is always specific to the set of work required to accomplish the project goals (Derenskaya, 2018). In other words, when project team deliver the deliverables of the project, the project ends as the team have achieved their goals (Denny, 2018). Most projects provide monetary income, such as construction or development (Nahod M. , 2012). Therefore, the scope of the construction industry is subjected to the scope of the project, rather than defining it as the scope of the product (Narvaez et al., 2016)

2.3 Scope in Construction Projects

The scope of the project has a great impact on all other aspects of the construction project, including time, cost, and quality (Cho & Gibson, 2001; Kumaraswamy & Chan, 1998; Love & Edwards, 2004). High-level pre-project planning can save up to 20% of costs and 39% of facility project schedules (Cho & Gibson, 2001). Therefore, to achieve the above outcomes, the scope of the project plays an important role in the construction industry (Camilleri, 2011). The first step in implementing a standardised project scope in a construction project, is a framework for establishing project policies, including managing its scope (Liberzon et al, 2013), establishing goals, specifying deliverables, setting limits and ensuring that the roles in the construction process are understood and actions derived from agency duties (Fageha & Aibinu, 2013). However, to define the scope of a project, scope management is a vital task to be performed in a construction project (Xia et al., 2015).

Scope management considers what need to be done in the project, why it shall be done, and how it should be done, and similarly, the scope of the project is closely related to the main limiting factors e.g. time, cost, quality, risk, and resources (Camilleri, 2011); it is established as a leading variable for technical performance and business generation, plays a key role in the definition of results, and represents the management of them. The scope control procedure has an impact on the variables that cause changes in the scope of the project and controls the impact of these changes and it can be a key issue for the success of the project (Nahod M. , 2012). Hence, the proper scope

management ensures that all changes and suggested corrective precautions are processed, and changes that harm the project are reduced or eliminated (Nahod M. , 2012).

2.4 Significance of the Defining Scope in the Construction Projects

Well-defined project scope must be established during the pre-project planning phase for a project to be executed successfully and to produce results that are satisfactory (Fageha & Aibinu, 2013). In addition to that, the authors have also mentioned that inadequate definition of project scope can lead to cost overruns, project delays, and general uncertainty, which will increase the possibility of excessive changes and rework during project execution (Fageha & Aibinu, 2013). The above statement has been supported by Assaf and Al-Hejji (2006) who stated that some of the main reasons for project delays in Saudi Arabia are related to changes in the scope of work, rework, and improper participation by all parties, which are signs of early project definition indeterminacy and stakeholder management issues. Furthermore, all project decisions are based on a thorough description of the project's scope, which also serves as the foundation for connecting the project's relevance to the advantages that should be realised upon its successful completion (Derenskaya, 2018). In addition to that, in the modern construction industry, to solve the problem of the unclear definition of the project scope, the American Construction Industry Association (CIA) has developed a scoring tool called the Project Definition Rating Index (PDRI), which can be used to assess the project definition completeness. However, Fageha and Aibu (2013) have mentioned that the principle of the PDRI tool is to allow the project planning team to determine the definition level required for each element in the project definition list.

Furthermore, Du Meng et al. (1997) found that during the front-end planning period, the cost performance of large-scale industrial construction projects with broader definitions increased by 19%, schedule performance increased by 13%, and change orders were reduced compared to comparable projects with fewer scope definitions 6%. In addition to that, Cho and Gibson (2001) found that the cost performance of large construction projects with a broader definition increased by 5%, schedule performance increased by 10%, and change orders decreased by 3%. Moreover, studies by Bingham et al. (2011a) have found that a large-scale fluid transportation project

with a broader definition during the front-end planning period had a 25% increase in cost performance, a 24% improvement in schedule performance, and a 7% reduction in change order definitions compared to smaller projects. However, with support of the above statements, Xia et al. (2015) found that with the increase in scope definition, through the development and testing of structural equation models, project performance was improved in terms of cost, schedule, and quality.

2.5 What is “Scope Indeterminacy” in the Construction Context

In today’s construction sector, the majority of project delays are caused by changes in project scope (Amoatey & Anson, 2017). Nelson (2015) stated changes to the current project scope that both parties (the client and the Contractor) are aware of and agree to refer to as scope changes. As a result, the above mention scope changes may be reimbursable changes or changes that were agreed by the Contractor to (or at least is aware of) without remuneration (Liberzon & Shavyrina, 2013). However, the point is that both the Contractor and client (Employer) are aware of the changes they have made and their impact on the project in terms of time cost and quality, and agree to include them (Al-Nuiami et al., 2010).

In addition, there is no universal definition of scope indeterminacy, but many authors have explained it in their way (Cho & Gibson, 2001). Scope indeterminacy is an unexpected alteration in the requirements and expectations of the client as the project progresses (Neimat, 2005). Furthermore, Bronstein (2010) has mentioned that the scope indeterminacy is generally develops with time and will not be noticed immediately and these changes usually come from seemingly insignificant small change requests accepted by the project team to satisfy the client (Employer). Moreover, The Project Management Institute determined the indeterminacy in scope as a gradual increase in the project scale, such as through requests for additional work, without the requirement for significant changes to the project cost or completion date (Reteana, 2014). The above statement was supported by Freshman-Caffrey (2014) and mentioned that, in professional services, scope changes mean that, the tasks required by the project exceed initial expectations. Finally, Hussain (2012) believes that the scope indeterminacy is a slow and informal amendment that will not change the deadline or adjust the overall budget in other ways, nor will it cause the project to

exceed its initial boundaries. Considering these definitions, it can be ultimately concluded that scope indeterminacy can be defined as unexpected and uncontrolled changes in major project requirements, which expand the initial boundaries of the project (Bano et al., 2012). Therefore, these changes take into account the completion date or timeline of the project and the budget (Amoatey & Anson, 2017).

2.6 Impact of project scope indeterminacy on the construction projects

The scope is the guiding principle that guides a specific project under the efforts of the project team (Polee & Samuel, 2011). Therefore, if there are any changes in scope, which need to be reduced or controlled, it may not only destroy the morale of the project, but also the entire project (Kerzner, 2006). However, a correctly defined and managed scope leads to the delivery of high-quality products to stakeholders at an agreed cost and specified time (Mirza et al., 2013). Therefore, changes to the scope have a direct impact on the project in terms of cost quality and time (Nahod M. , 2012).

As mentioned earlier, a major factor in an unsuccessful project is the lack of understanding or defining the in determine the scope of the project at the beginning of the project (Mirza, Pourzolfaghar, & Shahnazari, 2013) Even if the scope is correctly defined, if there is no guidance, the scope change can mislead the project in an unsuccessful way (Chen, Law, & Yang, 2009). Further, the above statement has been also supported by Mirza et al. (2013), and stated that recent studies have found that due to changes in scope and improper control of them, most projects have not achieved much success. Further, for many years, Ghana's real estate market has been tremendously supportive to the nation's socioeconomic development, although it confronts numerous risks, including project delays and scope changes, which have related impacts on the company's profitability (Amoatey & Anson, 2017). Therefore it is essential to manage the impact of scope changes in construction projects (Derenskaya, 2018). Moreover, the impact of scope indeterminacy can be analysed through the causes of scope changes in construction projects (wang et al., 2006).

2.7 Causes of project scope indeterminacy

The change in construction scope may be caused by various reasons and resources at different stages of the project; however, this research focuses on scope changes in both

the pre-construction stage and post-construction stage (Bassa et al., 2019). The causes for the changes may stem from external or internal requirement problems that may occur during the pre- and post-construction phases of the project (Gharaee, 2012). However, considering previous research number of causes have been identified and listed in Table 2.1

Table 2.1: Causes for Changes in Scope

No	Causes for Changes in Scope	Author Codes														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Project Priority		√	√												
2	Lack of Motivation and Decision								√		√	√				
3	impractical design															
4	labour shortages															
5	Project Risk			√	√	√										√
6	Quality Issues	√				√			√	√	√	√		√		
7	Lower Productivity											√				
8	Failure to reach customer expectations						√		√		√					
9	Poor effort estimation	√									√					
10	Less effort on defining scope	√										√				
11	Slow down project Progress															
12	poor performance															
13	unforeseen conditions															
14	technological uncertainty															
15	Unclear scope															
16	Change Cost	√		√		√					√	√		√	√	√
17	Project Resources			√		√										
18	Error generation rate						√		√							
19	Poorly written scope															
20	Effort wasted	√						√	√		√					
21	Project Failure	√	√	√						√						
22	Lack of Clarity															
23	scopes may be ambiguous															
24	Changes in Legislations					√				√					√	
25	Changes in regulation						√									
26	Client Change															
27	Rework			√					√			√	√		√	
28	Delays in Schedules	√		√		√			√	√	√	√	√	√	√	
29	Lack of Concentrate on defining the scope				√											
30	Communication and Coordination Gaps							√	√			√	√			

No	Causes for Changes in Scope	Author Codes														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

1 - McQuighan & Hammell, (2011); 2 - Article, (2013); 3 - Verner & Sampson, (2008); 4 - Zowghi & Nurmullani (2002); 5 - Madhuri & Suma, (2014); 6 – Berry et al., (2010); 7 – Bjarnson, Winuk, & Regnell, (2012); 8 – Bjarnason et al., (2011); 9 - Kaur & Sengupta, (2011); 10 - Neetu-Kumari & Pillai, (2014); 11 – Nabeel et al., (2013); 12 - Gosh, (2015); 13 – Rehman et al., (2010); 14 - Hans, (2013); 15 – Bano et al., (2012)

No	Causes for Changes in Scope	Author Codes																	
		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30			
1	Project Priority	√													√				
2	Lack of Motivation and Decision			√	√											√			
3	impractical design																		
4	labour shortages																		
5	Project Risk			√				√							√				
6	Quality Issue			√					√	√				√					
7	Lower Productivity				√	√		√											
8	Failure to reach customer expectations										√					√			
9	Poor effort estimation																		
10	Less effort on defining scope				√														
11	Slow down project Progress			√															
12	poor performance																		
13	unforeseen conditions																		
14	technological uncertainty																		
15	Unclear scope																		
16	Change Cost			√			√	√	√	√		√			√				
17	Project Resources				√				√	√		√							
18	Error generation rate				√									√					
19	Poorly written scope																		
20	Effort wasted									√	√								
21	Project Failure									√	√				√				
22	Lack of Clarity																		
23	scopes may be ambiguous																		
24	Changes in Legislations			√					√				√		√				
25	Changes in regulation		√						√										
26	Client Change																		
27	Rework				√	√					√								
28	Delays in Schedules				√	√		√	√	√	√		√			√			
29	Lack of Concentrate on defining the scope							√					√						

No	Causes for Changes in Scope	Author Codes															
		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
30	Communication and Coordination Gaps				√												
16 - Wohlin & Andrews, (2001); 17 - Wnuk, Regnell, & Karlsson, (2008); 18 - Ehsan, et al., (2010); 19 - Thakurta & Dasgupta, (2011); 20 - Wang, Gibson, & Al, (2006); 21 - Puhl & Fahney, (2011); 22 - Williams S., (2006); 23 - Hussain et al., (2010); 24 - Tesfaye et al., (2017); 25 – Winuk et al., (2016); 26 - Suma & Madhuri, (2013); 27 - Sauer, (2009); 28 - Ebert & De-Man, (2005); 29 – Williams et al., (2006); 30 – Bjarnason et al., (2010)																	

No	Causes for Changes in Scope	Author Codes														
		31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
1	Project Priority													√		
2	Lack of Motivation and Decision															
3	impractical design										√					
4	labour shortages										√					
5	Project Risk															√
6	Quality Issues		√	√		√				√						
7	Lower Productivity															
8	Failure to reach customer expectations					√										
9	Poor effort estimation	√														
10	Less effort on defining scope															
11	Slow down project Progress															
12	poor performance										√					
13	unforeseen conditions										√					
14	technological uncertainty											√	√			
15	Unclear scope												√	√	√	√
16	Change Cost	√			√	√	√	√								
17	Project Resources		√			√			√							
18	Error generation rate															
19	Poorly written scope													√		
20	Effort wasted		√													
21	Project Failure		√													
22	Lack of Clarity													√		
23	scopes may be ambiguous													√		
24	Changes in Legislations			√						√			√			
25	Changes in regulation										√		√		√	
26	Client Change															√
27	Rework															
28	Delays in Schedules	√	√	√			√									

No	Causes for Changes in Scope	Author Codes														
		31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
29	Lack of Concentrate on defining the scope							√								√
30	Communication and Coordination Gaps					√					√					
31 - Molokken-Ostvold & Jorgensen, (2005); 32 - Madhuri & Suma, (2014); 33 - Khan, (2006); 34 – Carter et al., (2001); 35 - Wich, (2009); 36 - Bhise, (2013); 37 – Lin et al., (2012); 38 -Dvir & Letcher, (2004); 39 - Kerzner, (2007); 40 - Chan and Kumaraswamy (2002); 41 - Shenhar (1993); 42 - Gurlen (2003); 43 – Turk (2010); 44 - Muhammad Nabeel Mirza et al (2013); 45 - Amoatey & Anson, (2017)																

According to the table, thirty (30) causes related to scope changes in construction projects have been found. The majority of the reasons are discovered during the pre-contract or post-contract stages. However, some of the causes can be traced back to changes in the country's legislation and regulations (Reteana, 2014). Changes in construction projects are unavoidable, which means scope changes are also unavoidable (Ciccareli, 2012). As a result, sustaining positive performance in the core Iron Triangle components of time, cost and quality, it is difficult to control these scope changes in construction projects (Pollak et al., 2018).

2.8 Maintaining Performance of Iron Triangle in construction projects

The Iron Triangle concept is the generally recognised markers of project success in the construction industries (Bryde, 2008). In today's competitive market, many construction projects are difficult to complete on time, on cost, and with high quality (Ciccareli, 2012). Therefore, the most well-known indicator of project success criteria is the Iron Triangle, which prioritises cost, time, and quality (Stojcetovic, 2013). According to Berssaneti and Carvalho (2015), Iron Triangle is linked to project management maturity. The above-mentioned statement has been proved by the studies of Müller and Turner (2007), and also, the authors have mentioned that both skilled and unskilled project managers have valued the Iron Triangle for the success in the construction projects.

Further, the Iron Triangle, also known as the Project Management Triangle or the Triple Constraint, is a critical part of how it can be thought about project success (Pollak et al., 2018). In another way, Stojcetovic (2013) has mentioned that the Iron Triangle is based on centre-to-the centre concept. The Iron Triangle concept is based

on the idea that the three constraints are mutually dependent on one another: improving quality will increase the amount of time needed, which will also increase cost, and a tight deadline may cause a loss in quality, which will increase cost (Narvaez, Mateo, & Fernandez, 2016). However, the majority of the researchers judged cost, time, quality, and stakeholder satisfaction to be the most important aspects that could influence the success of a building project (Mirza et al., 2013). Based on the opinions of some researchers, following Table 2.2 has been prepared and it explained the main significant features of the Iron Triangle in construction projects.

Table 2.2: Key Features of the Iron Triangle

Time	Cost	Quality
Time management is frequently essential for any project to be successful. Budget overruns on projects are typically caused by poor schedule management (Mirza et al., 2013).	Estimating costs, determining a budget, and controlling costs are all part of cost management (Mirza et al., 2013).	When a project is over, the time and cost trade-off challenge for the project manager is resolved, and quality and performance considerations take precedence (Mirza et al., 2013).
The methods that must be used to guarantee that the project is finished on schedule are referred to as project time management (Lim, 2000).	Part of project cost management, which ensures that the project is completed within the assigned budget, are estimating, budgeting, and controlling spending (Lim, 2000).	The Project Management Institute defines quality as the extent to which a group of inherent traits conforms to standards (Morris & Sember, 2008).
To estimate the project's duration, project team must first determine how long each project activity will take to finish. (Mirza et al., 2013).	All businesses work to keep costs down while maintaining and raising quality. However, it is quite challenging to accomplish both of these objectives at once. Because quality and price are related (Mirza et al., 2013).	Before making plans for them, a project manager must first grasp the quality expectations. As part of quality management, the project manager and project team must specify the planning requirements, determine how the requirements may be met, and estimate the costs and time requirements (Morris & Sember, 2008).
The most crucial element of project time management is planning, which is followed by control and execution (Mirza et al., 2013).	In times of cost management and budget cutting, the answer to quality enhancement may be irresponsible unable to afford that. However, enhancing a process' quality might aid in minimising flaws (Shenhar & Dvir, 2007).	Project quality management refers to the procedures and actions performed by the performing organisation to establish quality policies, objectives, and responsibilities so that the project fulfils the requirements for which it was undertaken (Lim, 2000).

Time	Cost	Quality
Planning for project schedules may stem from deadlines, customer (Shenhar & Dvir, 2007).	Costs are important for the business and in terms of competition (Pollack et al., 2018).	The project Contractor gives the long-term availability of the result priority since the project must be financially successful. It is not sufficient to merely complete the project on schedule and within the allocated budget; the work must also be of a sufficient calibre (Shenhar & Dvir, 2007).
When speed is crucial, quality and cost need to be matched. A project's cost will rise if it is completed more quickly since more resources will be used. Changing the time (schedule) can affect both the price and the quality. If a project has to finish by a certain date, quality might be compromised (Pollack et al., 2018).		One of the fundamental ideas of project quality management is that quality is planned in, not examined in. It is less expensive to plan for quality than to review job results, redo them, or fix problems to meet quality requirements (Pollack et al., 2018).
Every project can be broken down into a number of tasks. The project manager must first decide which tasks must be accomplished, how long they will take, what resources they will need, and what order they must be finished in order to produce the project schedule (Lim, 2000).		

Based on table 2.2, the most crucial component, according to the respected researchers, was time and other success elements of the uncommon project success criteria that were shown to be particularly essential in overall project success were cost and quality (Mirza et al., 2013). Furthermore, the amount of time required can be increased by the quality improvements, resulting in a rise in cost (Pollack et al., 2018). A tight timetable may result in a drop in quality and, as a result, a rise in cost (Morris & Sember, 2008). On the other hand, if no limits are imposed, changes that cause project rhythm disruption, rework, extension of project duration, and decreased productivity and morale of field workers will result in higher overall project costs (Schenzer, 2009). However, the validity of the Iron Triangle and the classic triple restrictions of time, cost, and quality, on the other hand, has been contested in academic and industry

project management literature (Shenhar & Dvir, 2007). Therefore, it has been discovered that effectively managing the Iron Triangle is critical to project success; nonetheless, study into the Iron Triangle is one of the most disregarded basics of project management (Bryde, 2008). In addition to that, time, cost, and quality are commonly acknowledged as the most important considerations in project performance measurements, as well as the performance of activities aligned with the project scope (Lim, 2000). As a result, it may deduce that the performance of these three primary components has a direct bearing on the project scope (Odeh & Battaineh, 2002). Refer Figure 2.1

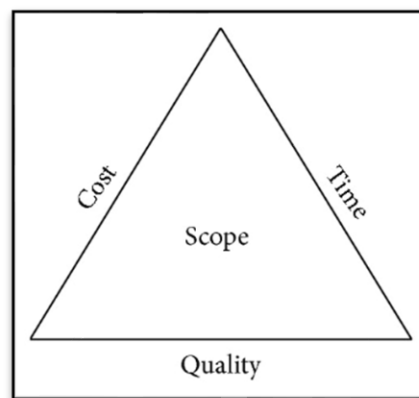


Figure 2.1: Impact of Scope for the Iron Triangle

2.9 Impact of Project Scope on Iron Triangle

The scope of a project is the foundation for estimating construction costs for budgeting, planning, and executing it on a specific period and at the needed quality (Al-Nuami, Taha, Al-Mohsin, & Al-Harthi, 2010). The above statement has been supported by Shenhar and Dvir, (2007); Turner and Bredillet, (2009) and additionally mentioned, that key stakeholders may consider projects that are delivered on schedule, on budget, and to the requisite quality according to the scope specifications as successful projects. However, considering the previous studies, it can be seen that certain writers making counter-arguments about the Iron Triangle components and project scope (Al-Nuami et al., 2010).

According to many previous studies, the traditional limitations of time, cost (budget), and quality have equally aligned with the project scope (PMI, 2009). Further, Pinto (2010) also stated the scope of the project is the fourth critical restriction in the Iron Triangle. In addition to that, according to the studies of Ebbesen & Hope (2013), the ultimate goal of a construction project is to meet the client's expectations, and that time, money, quality, and scope are the factors that must be considered to provide the best possible service (Refer Figure 2.2).

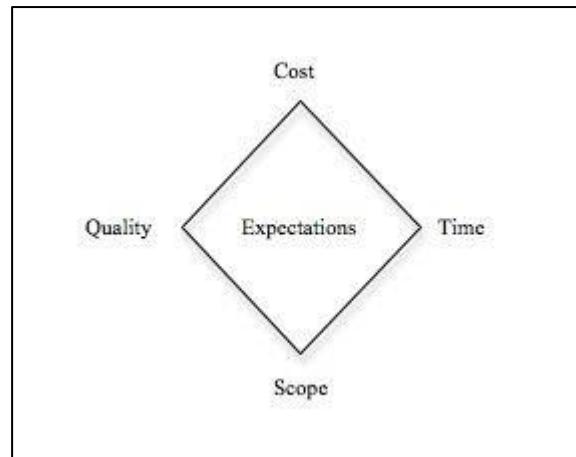


Figure 2.2: Major Component's to be considered in order to reach customer satisfaction

Even though, many researchers have considered scope as a component in the Iron Triangle instead of quality (Ebbesen & Hope, 2013). According to Schwalbe (2009), the authors have stated, scope, time, cost, and quality should be the determining factors. Similarly, quality is seen as an important limitation that shouldn't be disregarded and should be given equal weight as same as time, scope and cost (van-Wyngaard, Pretorius, & Pretorius, 2012). Further, some researchers have proposed that the Iron Triangle's third vertex be anything other than Quality, such as Scope (Bedewi, 2016; Schwalbe, 2009; van-Wyngaard et al, 2012). However, both of these concepts appear to be more closely tied to Quality compared to time or cost, and the Iron Triangle has emerged as a separate and significant concept in project management due to the ongoing interweaving of time, cost, and quality in the literature. (van-Wyngaard et al., 2012).

Even though; the theme of triple constraint has multiple interpretations, the literature has revealed a consensus that project quality, time, and cost are the three fundamental constraint variables in the Iron Triangle (van-Wyngaard et al., 2012). Therefore, when the Iron Triangle is used as a teaching tool to explain the relationship between time, cost, as well as other potential criteria, changes in project overall duration, budget and quality could possibly have an effect on project scope changes, the viability of requirements, and the quality of deliverables provided (Pollack et al., 2018)

2.10 Impact of Scope Changes on the Iron Triangle

The cost of scope changes might be up to four times that of the early development and deferred benefits and a reduced Return on Investment (ROI), as well as greater maintenance expenses and further projected loss, are examples of these costs (GurlenS, 2003). Further, Oladapo (2007) conducted a quantitative analysis on the time-cost impact of scope changes on Nigerian construction projects, finding that scope changes had a considerable impact on project time and cost overruns, accounting for roughly 79-68% of the time and cost overruns for the projects studied, respectively. Therefore, it can be highlighted, if a project takes longer to finish than projected owing to scope changes, it will take longer to achieve the deliverables, as well as incur additional costs and delay rewards, resulting in a worse ROI (Amoatey & Anson, 2017).

Furthermore, one of the most serious repercussions of scope change is that it can cause the project's timeline to be extended (Bassa et al., 2019). According to Dixon (2006), projects will take longer especially due to additional scope changes. Further, Thomas and Napolitan (1995) mention that changes in scope create a negative impact on labour productivity as well (Hanna et al., 2002a, 2002b; Hanna and Gunduz, 2004). In addition to that, authors have stated that, the scope changes commonly cause considerable delays in building projects, lowering the Contractor's labour productivity and lengthening the project's duration (Hanna et al., 2002a, 2002b; Hanna and Gunduz, 2004). However, based on previous research, impacts of scope changes have been listed in Table 2.3

Table 2.3: Impact of Project Scope Changes

Impact	Authors							
	1	2	3	4	5	6	7	8
Funding source changes					√		√	
Changes In technical difficulties		√	√					
Changes in internal politics	√							
External politics to the organisation	√							
Problems in Regulatory		√	√			√		
Changes in user need						√		
Changes in the overall time of completion		√	√	√		√	√	
Changes in complexity			√					
Changes in initial project expectations	√	√	√	√	√	√	√	
Changes in fund	√			√				√
Changes in materials				√				√
Changes in people				√				√
Changes in need of the project	√			√	√	√		√
Change in the overall project importance to the organization					√	√		
1 - Allison and Zelikow (1999), 2 - Pohlman et al. (2003), 3 - Pate-Cornell and Dillon (2001), 4 - Soman (2011), 5 - Hussain, Ehsan, & Nauman, (2010), 6 – Rehman et al., (2010) 7 -Muhammad Nabeel Mirza et al (2013), 8 -Arkes and Hutzel (2000)								

Moreover, Smallwood (2000) noted that scope changes results in material wastage. In addition to that, studies by Motel et al. (2003) have revealed the wastage of materials due to scope changes is directly subjected to the quality of work. Further, Zanelidin (2005) mentioned that, the likelihood of construction disputes occurring as a result of these quality reductions. Therefore, considering all information discovered through literature, it can be concluded that scope changes have a direct impact on the Iron Triangle in the construction projects and which requires some strategies to overcome negative outcomes from scope changes towards the maintaining performance of the Iron Triangle. As a result, based on the information gathered from the literature, it can conclude that scope changes have a direct impact on the Iron Triangle in construction projects, necessitating some strategies to mitigate the negative effects of scope changes while maintaining the Iron Triangle's performance (Odeh & Battaineh, 2002). Therefore, to maintain these components effectively in the project management process, scope management is an essential part to overcome the negative impacts of scope changes (Kumari & Pillai, 2014).

2.11 Scope Management in Construction Projects

Project scope management is becoming increasingly important in projects since it has become crucial to project control and elaboration (Lampa, et al., 2017). The initial stage in implementing a project scope management standard methodology in construction sector organisations as a framework for creating set of project policies, is to manage their scope (Liberzon & Shavyrina, 2013), establish objectives, set limits, specify deliverables, and ensure that roles in the construction industry are understood (Fageha & Aibinu, 2013). Scope management in this context aims to maintain project limitations, which can be a challenging endeavour given that project boundaries aren't always distinct and well-defined and can be altered by organisational, political, social, technological, and economic variables (Alexandra & Beus-Dukic, 2009).

Further, The PMBOK (2013) guide has presented scope management as a set of knowledge domains, with the project management is in charge of developing a set of processes that will ensure that all work is required, and only that which is required, to effectively finish the project. In addition to that, the scope of a project is strongly linked to major constraints e.g., time, money, quality, risks, and resources (Lampa, et al., 2017). The above statement was supported by Badariah et al. (2009) and stated that even little changes in scope can have significant consequences in terms of time, cost, and quality (Badariah et al., 2009). Therefore, scope management pays close attention to what changes have been made to scope projects, why it has been made, and how it has been made (Badewi, 2016). Similarly, overruns of costs and time become systemic when the scope is not clearly and properly specified, and scope change is a result, as well as the second greatest rework signal (Prieto, 2019). Therefore, as a result, proper consideration of scope changes is an important aspect of the scope management process to minimise negative effects and ensure project success while maintaining time, money, and quality (Institute of Project Management, 2008). In addition to that, PMBok (2013) has elaborated a framework regarding the scope management in the construction projects (Refer Figure 2.3).

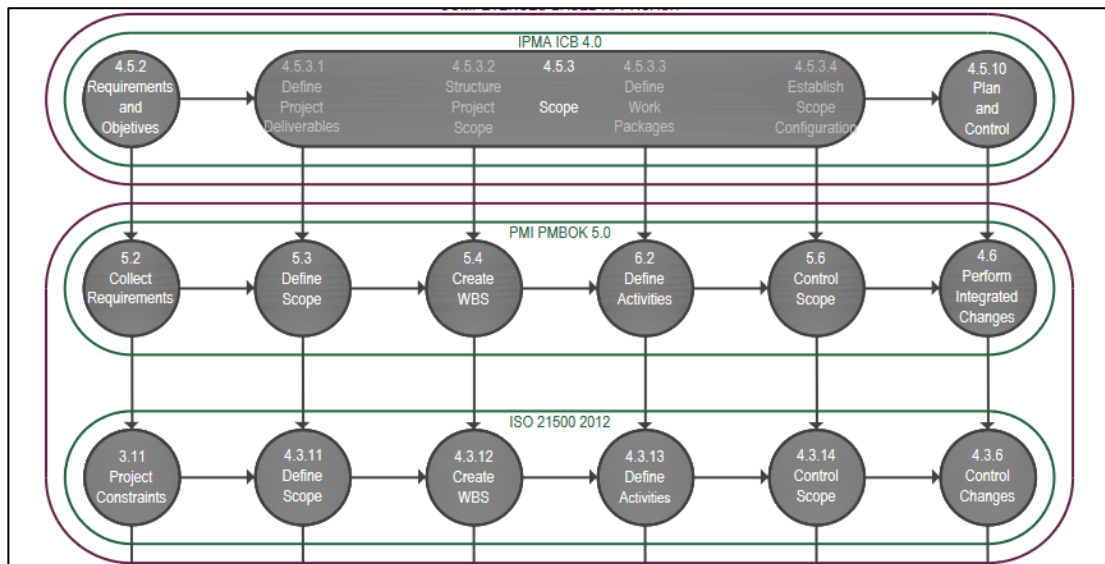


Figure 2.3: Project Scope Management Framework; Source PMBok 2013

PMBok (2013) has established important multiple steps in the scope management process based on figure 2.3. All of these procedures have a major impact on project scope management and project success. On the other hand, control scope changes have been included as a key phase in the process in this framework. Therefore, as a result, it can conclude that scope changes play a significant role in scope management (PMBok, 2013).

Moreover, as previously stated, project management's other facets, including time, quality, and cost, are connected to scope management (Lampa, et al., 2017). Even though, scope management is an essential part of project activities, a lack of tools to enable requirements collection might lead to changes in scope, because once a requirement is written, it becomes part of the project planning process (Di-Thommazo, et al., 2015). Thus, when the scope is not adequately specified, it leads to scope changes and frequent failures during the project (Kumari & Pillai, 2014). Further, cost overruns can occur due to the improper management of project scope changes (Prieto, 2019). In addition to cost overruns caused by scope changes, authorities frequently witness delayed completion and lengthy conflicts (Derenskaya, 2018). Therefore, it can be concluded that scope management strategies are required to manage scope changes in construction projects and to control the negative consequences of scope changes (Cerezo-Narvaez ET AL., 2016).

2.12 Scope Management Strategies to Manage Scope Changes in Construction Projects

Scope Management Strategies are used by the project teams to minimise and control scope changes in construction projects (PMI 2013). Furthermore, scope management tactics can be used on projects when the scope has already been adjusted to efficiently tackle problems that have arisen as a result of the scope changes (Nabeel et al., 2013). However, several scope management strategies have been identified based on previous research, as indicated below. Refer Table 2.4

Table 2.4: Scope Management Strategies to Control Scope Changes

Scope Management Strategy	Authors													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Identify requirements properly	√			√										
Identify Stakeholders	√					√								
Identify Project Drivers	√													
Examine the Scope Statement	√								√					
Queuing Theory - reducing the impact of waiting periods on critical work packages								√						
considerations of time										√				
Communicate what to do and how to deliver the results			√		√		√		√					
Identify both activities and results			√		√		√						√	
Consolidate requirements			√		√		√							
Consideration of budget										√				
Complete prevention of a scope		√												
The project manager needs to be vigilant												√		
Facilitate the assignment of roles and responsibilities			√		√		√				√			
Avoid the omission of tasks and their duplicity	√		√		√		√							
Guide the realization of both budget and schedule			√		√		√							
Document learned lessons			√		√		√							
Reference improvement processes		√	√		√		√							
Understand the client's vision properly												√		
Be unambiguous													√	
Be accurate													√	
Take both preventive and corrective actions			√		√		√					√		
Analyse requested changes impact, studying its conditions and traceability			√		√		√							v
Influence factors that cause scope changes			√		√		√							

Scope Management Strategy	Authors													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Prescriptions for client change.														✓
Prescriptions for unforeseen risks														✓
Prescriptions for unclear scope														✓
Define both work and deliverables			✓		✓		✓							
Analyse requirements providers			✓		✓		✓							
Study agreed requirements impact			✓		✓		✓							
Examine assumptions and constraints			✓		✓		✓							
Consideration of specification										✓				
Consideration of customer satisfaction										✓				
maintaining the status quo within the organization.										✓				
Include both intermediate and final deliverables characteristics, specifications and acceptance criteria, preliminary cost estimates and schedule milestones			✓		✓		✓							
Integrate changes control			✓		✓		✓							✓
Facilitate impact analysis and communication	✓		✓		✓		✓		✓					
Measure performance			✓		✓		✓							
Identify variations			✓		✓		✓							
Get a formal acceptance			✓		✓		✓			✓				
Review deliverables			✓		✓		✓							
Ensure agreed changes are properly processed			✓		✓		✓							
1 - Mirza, Pourzolfaghar & Shahnazari (2013), 2 - Gurlen (2003), 3 -Cerezo-Narvaez, Otero-Mateo, & Pastor (2016), 4 - Clancy (1995), 5 - IPMA (2015), 6 -Poole and Samuel (2011), 7 - PMI (2013), 8 - Levy and Globerson (1997), 9 - Chung-Suk & Gibson (2007), 10 - Kerzner (2006), 11 - Doll (2011), 12 - Clark (2014), 13 - Turk (2010), 14 - Amotey (2017)														

According to the table, 41 strategies were identified to manage the indeterminacy of scope in construction projects. Indeterminacy of scope, on the other hand, might have an impact on many building projects. Scope indeterminacy affects the majority of public construction projects, resulting in a slew of poor outcomes in terms of time, money, and quality (Khan & Abdul-Qadir-Khan, 2015).

2.13 Cost overruns, quality issues and delays in Public Construction Projects

Time delays and cost overruns frequently hurt national economies, cause significant financial losses, and stifle the development of public construction projects (Assaf & Al-Hejji, 2006). The above has been supported by several studies in the construction

industry (Gharaee, 2012). A long-term assessment of a variety of public projects in the United States' state of Nevada revealed the negative and costly consequences of delays (Kaufmann et al., 2007). Furthermore, between 2000 and 2013, the state of Qatar saw a 72% of time delay and 54% of cost overrun on public projects (Senouci et al., 2016). These time delays and cost overruns impacts are common in public-sector project management as the works are done at the wrong time (years before the project's execution) by the wrong individuals, who consistently disregard the interests of key stakeholders (Hussain et al., 2012) Further, during the 1990s, massive cost overruns on public projects, especially railway construction, prompted the quality assurance effort (Olsson , 2015).

Moreover, several causes can be found in public construction projects which lead to cost overruns and delays (Hussain, Farooqui, Umer, & Lodi, 2012). Al-Momani (2000) looked into the factors that caused delays in 130 public construction projects in Jordan between 1990 and 1997. Furthermore, according to the competitive bidding method, the Contractor with the lowest tender price wins the project; this is a major factor that contributes to poor performance and delays in public construction projects (Aziz & Abdel-Elkhalek, 2016). From the client's perspective, clients (Employers) in general, and public sector authorities/clients in particular, rarely adhere to the prescribed maintenance schedule, therefore past maintenance and replacement costs data, even when available, are suspect (Nicolini et al., 2000). Scope changes, additions, or omissions/deletions of particular works indicated in the original contract are the most common reasons for delays in public projects, and the majority of them are issued by the client (Moura et al. 2007). Moreover, from the Contractor's perspective, delays in public construction projects were found to be caused by inexperienced Contractors in 43% of cases, followed by insufficient oversight in 21% of cases and inaccurate Contractor potential in 14% of cases (Shah, 2016). However, according to Larshen et al. (2016), errors or omissions in construction work, unsettled or insufficient project planning, unsettled or lack of project funding, delay or lengthy process times caused by other authorities, and poor identification of actual needs were among the five main causes of delay identified in a study of the effect of 26 factors on time, cost, and quality in public construction projects. Furthermore, according to Al-Momani (2000), the

primary causes of delays in the construction of public projects, were designers, user changes, weather, site circumstances, late delivery, economic conditions, and an increase in quantity. Even though, Shebob et al. (2012) have a different view on the causes of delays and cost overruns in public construction projects. Authors have explained due to environmental, topographical, and technological constraints, the causes and impacts of delay factors in public construction projects differ from country to country, and to mitigate the impact of delays in any construction project, it is vital to identify the true causes of delay in anticipation of the effects of globalisation and the technological differences between developing and industrialised countries (Shebob et al., 2012). Finally, Abdalla and Battaineh (2002) performed a survey of construction Contractors and consultants to determine the key causes of delays in public construction projects with traditional types of contracts and owner involvement, lack of Contractor expertise, budgeting and payments, sluggish decision making, labour productivity, poor planning, and subcontractors were among the top 10 most critical factors, according to the results of the poll. However, changes that are imposed on public projects, as well as a lack of clarity about the scope and objectives of the work, are also a problem (Senouci, Ismail, & Eldin, 2016).

2.14 Impact of scope Indeterminacy in public Construction projects

The preparation of the scope definition is a crucial sub-process of the early project planning process (Amoatey & Anson, 2017). Scope definition is the process of defining and preparing projects for execution (Cho & Gibson, 2001). At this crucial stage, the project's risks are evaluated and its special execution approach is established (Kaufmann et al., 2007). If the scope is not properly defined and specifically for the client (Employer) needs are not determined when the contract documentation is finished, then the essential changes during the construction activities may result in rework, which could hurt project cost and schedule (Peter et al., 2004). When it comes to public-sector construction projects, claims due to scope indeterminacy in public construction projects can exceed 200-300% of the project cost, and if this could have been avoided, it would have saved the government a lot of money (Kaufmann et al., 2007). In addition to that, uncertain scope, challenging financial conditions, and the addition of works all contributed to public construction projects being high-risk

(Shebob et al., 2012). Furthermore, additional reworks in public construction projects may result in overtime, additional resource employment, timetable slippage, or project scope or quality decreases (Peter et al., 2004). According to Turner, the goal of scope management in public construction projects is to complete an appropriate or sufficient quantity of work while avoiding needless work and ensuring that the work completed meets the specified business objectives (Turner J. , 1999). Therefore Peter, Love, Irani, and David, (2004) have mentioned that, to keep the project within budget in a public construction project, a lot of reworks on the documentation have to be done to eliminate scope indeterminacy.

However, several studies show that scope indeterminacy has a significant impact on public construction projects. At first studies, by Mahamid (2013) have explained that scope changes can lead to delays and cost overruns in public construction projects. In addition to that, studies by Koskela (2002) have elaborated on scope planning, and scope definition plays a major role in public construction projects. Moreover, studies by Shrestha, Burns, and Shield (2013) have stated that the scope definition, coordination of roles and duties among relevant parties, initial estimation and contingency planning, and monitoring and control systems are the main causes of time delays and cost overruns. Further, Creedy (2005) has explained reduced scope change saving money on public projects. This was supported by Noman et al. (2018) and stated that changes in the scope of the project are one of the most prevalent delay issues in public sector building projects in Saudi Arabia. Similarly, Al-Khalil and Al-Ghafly (1999) and Hussain. (2012) have mentioned that scope changes have a direct impact on the public construction projects in terms of time cost, and quality. Finally, according to the above studies, scope indeterminacy has a significant impact on the causes of delays in public construction projects and, if scope changes and additional work are prioritised at the proper moment, delays in public construction projects can be significantly reduced (Hussain O., 2012)

2.15 Public Building Projects

The construction sector is the backbone of practically every aspect of social progress and most public building construction projects are monopolistic goods (Flyvbjerg et al., 2002). public building construction projects operate similarly, but through

competitive bidding (Khan & Abdul-Qadir-Khan, 2015) As a result, most of the public building projects have never been created before, amid strict time constraints, and with construction teams that have never collaborated before (Hussain, 2012). Large public building construction project time and cost increases appear to be a global phenomenon, with no reduction in the last 70 years and an average cost overrun of 28%, causing project delays (Flyvbjerg et al., 2002, 2003).

Government spreads out finance for many public building projects in a country (Creedy, 2005). public building construction projects are one of the most significant tools for a country's economy since it enables strategic ambitions and goals to be translated into reality from simply written plans (Alsuliman, 2019). Public safety, national security, telemedicine, e-government, distant learning, and utility applications are among the applications that enable economic and societal benefits from public building projects (Ameh, Aliu, & Odusami, 2010). Further, as is explained above the capital at the national and provincial levels has been invested in the same way, and all government and public service construction projects must be funded by government funds (Assaf & Al-Hejji, 2006). As a result, no single financial source can fund all projects at the same time (Shebob et al., 2012). Moreover, the effectiveness of a country's work and its ability to fulfil its development goals are reflected in the performance of public projects in that country (Alsuliman, 2019). Therefore, there may be a demand for public building construction projects that emphasise the economic benefits of infrastructure development in the host community (Noman et al., 2018).

2.16 Defining Project Scope in Public Building Projects and Responsible Parties.

In public projects project scope define responsibility is rights and obligations of the procurement entity (PE) (Procurement Guideline, 2006). Further, according to the Standard Bidding Document 2 (2007), the Employer defined the scope of a project as construction of works in a bidding data. However, the scope always is connected with the Employer Requirement (ER) which is defined by the Employer, referred to as the “works” for the design construction, commissioning and remedying defects of works (ICTAD SBD4, 2003) However, if domestic civil works contracting and goods supply capabilities are well established, contract scope and sizes should be defined in a way that allows domestic firms to compete effectively (Procurement Manual, 2006).

The scope in the public building projects will be set by the Engineer based on the Employer's requirements, and the responsibility for determining scope will be shared by the Employer and the Engineer (Standard Bidding Document 2, 2007). When it comes to design and build contracts, the Design Build Contractor is also responsible for specifying the scope, as stated in Sub Clause 5.1 (Standard Bidding Document 4, 2003). Procurement Manual (2006) also stated when implementing scope, a paragraph defining the scope of work is often included at the start of the specifications for works contracts, and it is typical to include a list of drawings. The scope of the Contractor's obligations must be defined if the Contractor is responsible for the design of any portion of the permanent works (Procurement Manual, 2006).

2.17 Chapter Summary

In the coming years, the global construction industry will become more complex. Public building projects are important in the construction business as they focus on public services and programmes. Public projects are subject to increased scrutiny since they are funded primarily by tax revenues. Therefore, greater transparency in the tendering and contract award procedures is crucial. Public projects frequently publicise their needs and solicit bids openly and transparently. Further, the success of these public-building projects is dependent on a well-defined scope. However, due to the ambiguous scope of these public building projects, they have been largely ineffective in terms of enhancing the impact on the Iron Triangle. Therefore, the goal of this study is to determine the impact of the Iron Triangle as a result of scope indeterminacy and to propose methods to mitigate scope changes.

3.1 Introduction

The second chapter described in detail existing literature on the research topic's circumstances. The purpose of the next third chapter is to select the appropriate research methodology to attain the previously stated study goal. For this purpose, a comprehensive explanation of the research design, approach and method in terms of available and adapted methods, and justification for adaptation is discussed. The research process, as well as data collecting and analysis approaches, are also described.

3.2 Research Design

A research design is the 'procedures for collecting, analysing, interpreting and reporting data in research studies (Creswell & Plano Clark 2007, p.58). Similarly, offering an appropriate framework for research is the goal of the research design (Jilcha, 2019). Therefore, as it impacts how pertinent data for research will be acquired, the decision to be made about the research approach is a highly crucial one in the research design process which comprises multiple related considerations (Aaker et al., 2000). Moreover, Ram (2010) has described research design as a master plan that specifies the methods and procedures for gathering and analysing the required data. The above statement was supported by Kothari (2004), who explained research design can be defined as the overall plan for identifying the technique, structure, and strategy of the research to uncover different instruments to tackle the problem and minimise discrepancies. Further, the research design is the sight of strategy for linking conceptual concerns of research to relevant empirical research (Boru, 2018). In other words, the study design outlines how the necessary data will be gathered, evaluate, analysed, and used to address the research question (Grey, 2014). However, when a conclusion is accurate or true, a research design is legitimate, and research design is the conceptual blueprint within which research is conducted (Akhtar, 2016). There are basically three research design types, according when there to Robson (2002): exploratory, descriptive, and explanatory.

3.2.1 Exploratory

Exploratory research is carried out when there is insufficient knowledge and information about specific a phenomenon or a problem that hasn't been precisely

characterised (Saunders et al., 2007). Its aim is not to provide appropriate solutions to the research main questions, but rather to examine the research issue in various views and depths (Brown, 2006). This type emphasis is on fresh topics that have received little or no prior research (Boru, 2018). Therefore, Exploratory research establishes the first research concept, sampling methodology, and data collection method, setting the foundation for more conclusive research even under the most extreme circumstances (Singh, 2007).

3.2.2 Descriptive

Descriptive research aims to provide a picture of a scenario, or event, or to show how various elements are connected and how something happens naturally (Blumberg et al., 2005). On the other hand, descriptive studies are best suited for a very fresh or unexplored research subject since they can explain why an event occurred (Punch, 2005). However, alternative research designs, such as explanatory or exploratory approaches can be recommended in situations where descriptive data is abundant (Brown, 2006).

3.2.3 Explanatory

The main aim of the explanatory research is to describe and account for the descriptive data (Singh, 2007). On the other hand, Explanatory studies, seek to answer "why" and "how" questions, whereas descriptive studies may focus on the questions of "what" (Grey, 2014). To ascertain the true reasons and outcomes of a phenomenon, it builds on descriptive and exploratory research. Additionally, the explanatory study seeks out major causes for the question and explanations, as well as data to back up or contradict a theory or prediction and it is done to discover and present certain correlations between different aspects of the event being studied (Blumberg et al., 2005).

3.2.4 Selected Design for this Research

The focus of the research is to see how scope indeterminacy affects the Iron Triangle in public building projects. The impact on the Iron Triangle owing to scope indeterminacy needs to be explored to the public building projects due to a lack of research. As a result, the exploratory research design is appropriate for this study. On the other hand, the study question is based on how scope indeterminacy affects the

Iron Triangle in public building projects. Since the question is framed around the phrase 'how', Explanatory design is also appropriate for this study. Therefore, this study is conducted using both exploratory and explanatory research designs.

3.3 Research Approach

A research approach is a strategy that can help you do methodical and effective research. According to Schwardt (2007), a research approach is a view of how an investigation should go, and it entails an examination of the assumptions, principles, and methods in a particular method of investigation. According to Teddlie and Tashakkori (2007), the different types of problems that are worth looking into are defined and explained by approaches, along with what makes a problem a researchable one, testable hypotheses, how to frame a problem so that it can be investigated using particular designs and procedures, and how to choose and develop suitable data collection techniques. Further, according to Creswell (2009), there were three main research approaches: qualitative, quantitative, and mixed. These key study methodologies each have their own beliefs on how individuals acquire scientific knowledge and what constitutes useful and effective knowledge, based on various philosophical ideas (Symeou & Lamprianou, 2008).

3.3.1 Qualitative Approach

Qualitative research is the systematic collection, organisation, and analysis of textual data derived from speech or conversation and it is used to explore the meanings of social phenomena as experienced by people in their natural environments (Malterud, 2001). In order to explore the meaning of experience in a study sample, qualitative research methods, which are similar to work with written materials, typically transcriptions of individual interviews or focus group discussions (Grossoehme, 2014). The qualitative methodology focus on how to frame a topic for exploration, the most appropriate problems to investigate, how to build acceptable data creation, and how to establish a logical connection between the problem, data gathered, analysis, and conclusions derived (Samuels, 2019). In additionally, it aims on explaining people's opinions and statements; it may be the most accessible way for chaplains to enter the realm of research (Boru, 2018). The purpose of all science is to use observation to find better solutions to the questions about the evolution of an experience or phenomena,

while the aim of social science is to provide new or alternative frameworks for understanding how social realities are experienced by people today (Jackson et al., 2007).

3.3.2 Quantitative Approach

The quantitative research method begins by describing differences between persons in terms of "standard" variables that apply to everyone, even though various people have different quantities or amounts of the variables (such as intelligence or extraversion or tolerance for ambiguity) (Cropley, 2021). Quantitative research analyses numerical data using mathematical models and statistical data to produce more objective numerical results and research findings define interpersonal interactions and provide answers to whether a relationship is satisfying, good, or bad (Moore, 2016). Then, by determining how much of each variable various people have, it seeks to establish the existence of cause-and-effect relationships among the variables, sometimes using highly standardised samples of questionnaires (Apuke, 2017).

3.3.3 Mixed Approach

In a mixed-methods study, qualitative and quantitative research and data are combined or incorporated into one study (Creswell, 2014). For example, a multi-method study may compare two quantitative methods, so it is a quantitative study. Hence, mixed-method research uses qualitative and quantitative methods simultaneously or sequentially (Venkatesh, Brown, & Bala, 2013). Quantitative data comes from closed-ended data sources such as questionnaires, or psychological instruments, whereas qualitative data comes from open-ended sources with pre-designed experiences and responses (Creswell, 2014). Numerous terminologies, such as integrating, synthesis, quantitative and qualitative techniques, multimethod, and mixed methodology, are used to describe this approach, however the phrase "mixed methodology" is most widely used in contemporary works (Tashakkori & Teddlie, 2010).

3.4 Selected Approach for this Research

In the domain of scope indeterminacy in building projects, a lot of research has been conducted on the main three approaches. However, interviews dominate the study to attain the final aims, despite all of the methodologies, due to a lack of access to

quantifiable data the first phase of the study needs to be carried out through the case study analysis. Following the case study analysis, a questionnaire survey needed to be conducted to assess the remaining objectives of the study. As a result, mixed approaches were used for additional research in this study.

3.5 Research Strategies

Analysis concepts, theoretical construction, formal analysis techniques, and operating processes are all required by research strategies used to improve strategic management research (Cropley, 2021). There are several research strategies such as quasi-experiments, surveys, experiments-laboratory, case study research, action research, ethnography and grounded theory (Kagioglou et al., 2000).

3.5.1 Case Studies

The case studies can be used to investigate and comprehend difficult situations. It is an effective research method, especially when a complete and in-depth study is necessary (Zainal, 2007). It refers to the use of specific qualitative research methods in particular situations and this strategy is usually limited to a single setting, theme, or event (Rebolj, 2013). The research in scope indeterminacy in public building projects is rare. As a result, the causes of scope indeterminacy found in the literature review for general construction projects must be narrowed down to public construction projects. Hence, case studies were used to conduct an in-depth investigation in order to pinpoint the root causes of the public construction projects.

3.5.2 Surveys

3.5.2 Survey Strategy

The survey research strategy focuses on big and small groups of people, with samples from these groups being selected and studied (Kumar, 2011). Furthermore, surveys are useful instruments for gathering information on a variety of viewpoints in large groups (Jones et al., 2013). As a result, surveys were used to conduct this study due to the large number of factors that were examined utilising the choice of construction professionals in public building projects. Calculating the Iron Triangle impact is a countable approach in this study. Survey techniques are the greatest alternatives for this since the precision of statistical data is considerably more reliable for this research discovery since the approach is countable.

3.5.3 Selection of Sampling

The researcher selects a location where there are likely to be a large number of individuals, making it difficult to make contact with everyone. As a result, the researcher selects some people, known as sampling (Akhtar, 2016). In social research, the term "population" refers to all of the people who might question for information regarding the topic is looking into (Symeu, 2008). Purposive sampling was used to choose the sample for this study, which primarily focused on experts with extensive expertise in public building projects. The participants in the aforementioned sample will be interviewed and questioned, and their opinions will be analysed as part of the data analysis. The major experts in this study were Architects, Quantity Surveyors, Project Managers, Engineers, Town Planners, and Contractor professionals who were directly involved in the specific situations.

3.6 Qualitative Data Analysis Techniques – Case Content Analysis

The term "content analysis" refers to a group of methodologies for deciphering storied texts or visual data. People give their own opinions to help organise and make sense of their experiences, and their storied reports are functional and meaningful, according to a frequent assumption of creative approaches (Figgou & Pavlopoulos, 2015). In another hand, content analysis determines the content of an unstructured message, regardless of whether the data is text, image, symbol, or voice (Gheyle & Jacobs, 2017). Further, the above-mentioned analysis technique, is distinct for a variety of reasons, as stated in an often-accepted definition: it is a research technique that can go from text (or other relevant objects) to the context in which it is utilised to produce reproducible and effective inferences (Krippendorff, 2004). As a result, content analysis can be utilised to analyse data acquired from case study reviews.

3.7 Quantitative Data Analysis Techniques – Relative Important Index (RII)

Quantitative procedures generate a significant quantity of data. To carry out the quantitative analysis, needs to be used graphical tactics such as generating charts, graphs, and measurements with statistical functions like median, standard deviations, mean, and mod. A questionnaire survey was used to collect the dataset or quantitative statistics for the investigation and the information gathered from the questionnaire

survey was analysed using the Statistical Package for Social Sciences Software (SPSS software).

The researchers employed the Relative Important Index (RII) as a quantitative data analysis technique in this study to analyses quantitative data.

$$RII = \frac{\sum W}{A \times N} \times 100\%$$

Where W: Constant expressing the weighting given to each response; A: The highest weighting; N: Total number in the responses

3.8 Research Process

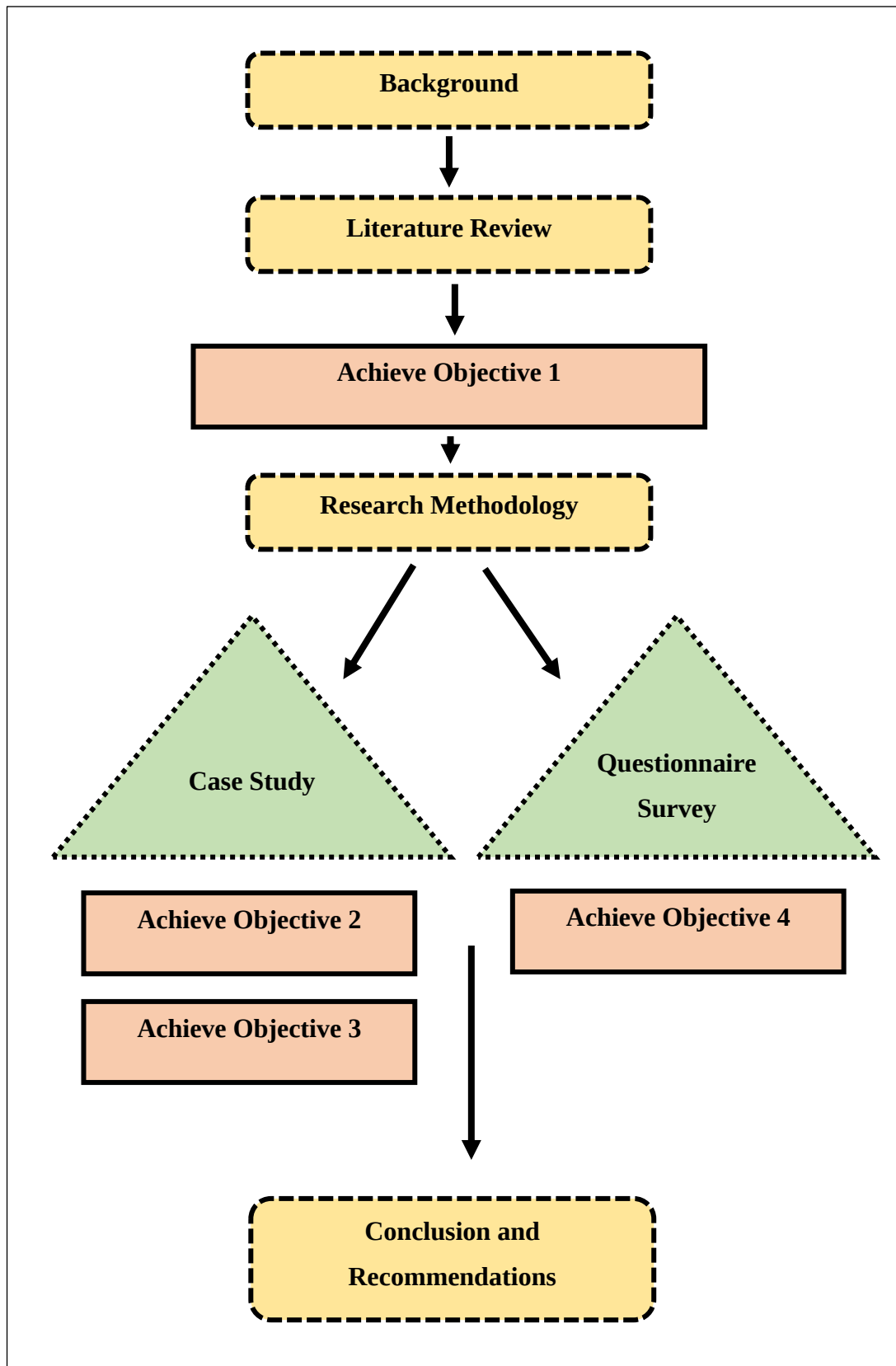


Figure 3.1: Research Process

3.9 Summary

Overall, by identifying the research design, research approach, research process, and research methodologies, this chapter has examined and systematically justified the research methodology. Furthermore, this study was conducted using a mixed approach, with data collected through case study analysis with selected expertise and a questionnaire survey of a wide sample.

4.1 Introduction

This chapter constructs the research findings derived from data gathered through interviews with construction professionals. The findings from the preceding chapter served as the foundation for interview guidelines. The analysis is organised around the four case studies and one questionnaire round that were used to collect data.

4.2 Phase I - Case Studies

Case study analysis, which includes four cases based on scope indeterminacy in public building projects, was done as the study's main empirical data collection phase. In each case, four interviews were conducted with the experts who were enrolled in the case. The following sub-sections show the objectives, background, findings, and analysis of case studies.

4.2.1 Objectives of Case Studies

The case study aims to discover the reasons for scope changes in public building projects, as well as the appropriate techniques for minimising scope changes. The offered cases, on the other hand, have highlighted four notable incidents in public building projects involving scope changes. As a result, the causes and mitigation solutions for each occurrence were identified and analysed by the in public building projects. Furthermore, the impact of the Iron Triangle was evaluated through case studies analysis in further phases by taking into account the causes of scope changes which were identified in case study analysis.

4.2.2 Background of the Cases

The empirical study was carried out based on four recent building construction projects under the government of Sri Lanka based on solicited proposal scheme. Three projects were funded by Treasury and one project was funded by semi government organisation. Out of four cases three projects have been completed, and one project is in the defect liability period of the contract. The four scenarios were chosen based on scope changes in public building projects. The improvements were submitted to alterations made by the client's (government) party, and the Contractor submitted claims against the scope changes according to the provision of the contract. In addition,

the Contractual characteristics and physical components of each project are described below (refer Table 4.1);

Table 4.1: Background of Case Studies

No	Case Code	Procurement Method	Client	Contractor
1	CS. A	National Competitive Bidding	A Government Organisation	CS2 Grade Contractor
2	CS. B	National Competitive Bidding	A Government Organisation	CS2 Grade Contractor
3	CS. C	National Competitive Bidding	A Government Organisation	CS2 Grade Contractor
4	CS. D	National Competitive Bidding	A Government Organisation	C1 Grade Contractor

Description of Case – CS. A

- ❖ Project location : Western Province - Colombo
- ❖ Procurement method : National Competitive Bidding,
- ❖ The Employer : A Government Organization
- ❖ The Contractor : CS2 Grade Contractor
- ❖ The Engineer : Semi Government Organization
- ❖ Project components : Construction of a Market Building
- ❖ Contract Sum (LKR) : 4,507,730,959.60
- ❖ Contract Duration (Months) : 24 (728 Days)
- ❖ General Condition of Contract : CIDA/SBD/02 Second Edition Revised January 2007
- ❖ Commencement : 03rd January 2018
- ❖ Schedule date of Completion : 31st December 2019
- ❖ Actual completion : 17th November 2020
- ❖ Status of the project : Successfully Completed

While the Contractor was proceeding with his obligations, the Employer identified additional works to the contract which are not in the original scope of the project as follows.

1. Construction of 26 Nrs retail shops and Grocery shops.
2. Construction of 08 Nrs Cafeteria spaces

3. Access road improvement to manning market project
4. Chain link fence around the boundary including chain link swing gate

The Contractor submitted a cost proposal for the above additional works in the amount of Rs. 297,683,155,03

Further, based on the above scope changes to the contract, the Contractor submitted an extension of time, cost and profit incurred by the delays in issuing details and variation of the works of buildings. The Contractor's claims of 207 days' time extension and Rs. 367,096,092.16 prolongation cost and Profit are under Clause 19.1 of the Conditions of contract.

Description of Case – CS. B

❖ Project location	: Western Province - Colombo
❖ Procurement method	: National Competitive Bidding,
❖ Project components	: 608 Housing units for Government Employees
❖ The Employer	: A Government Organisation
❖ The Contractor	: CS2 Grade Contractor
❖ Contract Sum LKR	: 4,499,200,000.00
❖ Duration (Months)	: 36
❖ Commencement	: 07 th November 2015
❖ Schedule date of Completion	: 6 th November 2019
❖ Actual Completion	: 20 th October 2020
❖ Status of the project	: Successfully Completed
❖ General Condition of Contract	: CIDA/SBD/04 First Edition- November 2002

This contract has been awarded to a CS2 grade Contractor on 07th November 2015 for design construction and remedying any defects of 608 housing units for government servants at the Western Province for a contract price of Rs. 4,499,200,000,00 excluding VAT, NBT, CIGF, ABC Authority levy, and other customs duties. Accordingly, the total contract price for the scope of work is defined in the condition of contract.

While the Contractor was proceeding with their tasks, the Employer identified additional works/Variation to the contract which was not in the original scope of the project. It was noted that, as per the building regulation provide one car parking unit enough for two housing units which are below the 70sq.m, area housing unit. Accordingly, in this project 304 housing units were below the 70 sq. m. However, the Employer decided to improve the quality of the housing units. Hence, change the scope as follows,

1. To provide one parking slot for each house
2. To provide Swimming pool facilities
3. To provide a balcony for each pantry

The Contractor submitted a cost proposal for the above additional works in the amount of Rs. 674,526,079,93 which is the net variation of 14.99% of the total contract sum. Further, the following disputes were raised by the Contractor and referred to the DAB.

1. Additional costs associated with Extended Preliminaries
2. Additional cost incurred due to price escalation during the extension of time given for Variations/additional works instructed

Description of Case – CS. C

❖ Project location	: Colombo
❖ Procurement method	: National Competitive Bidding,
❖ Project components	: 1000 Housing units
❖ General Condition of Contract	: CIDA/SBD/04 First Edition- November 2002
❖ The Employer	: A Government Organization
❖ The Contractor	: CS2 Grade Contractor
❖ Contract Sum LKR	: 5, Bn
❖ Duration (Months)	: 24
❖ Commencement	: 02 nd November 2016
❖ Schedule date of Completion	: 3 rd November 2018

The Contractor submitted the Performance bond and Advance payment Guarantees on 28th November 2016 and 09th January 2017 respectively.

Accordingly, released the Mobilization Advance (First Instalment) of 10% of the contract price Rs. 420 Mn (approx.) to the Contractor on 22nd January 2017.

On the Contractor has commenced the work of the project has got delayed for a long period (21 months' construction period has been delayed) due to the unforeseen circumstances.

On 10th August 2018 transferred this project to the Ministry of PQR for implementation.

The new Employer changed the scope from 1000 numbers housing to 320 numbers and renegotiated with the Contractor on prices. The Contractor submitted the price BOQ for 320 nos housing units and both parties have signed the new contract agreement.

28th April 2019 – A fresh contract was signed, between the New Employer and the Contractor

- ❖ New Intended Completion date : 31st December 2019
- ❖ Status of the project : Successfully Completed
- ❖ Revised Contract Sum (Mn) : 1920

The Design & Build Contractor of the project has submitted a claim amounting to a total Sum of RS 461,503,102.28 for compensation of losses or damages suffered due to the Restructuring of the contract & Curtailment of the Scope of work.

Description of Case – CS. D

- ❖ Project location : Colombo
- ❖ Procurement method : National Competitive Bidding
- ❖ Project components : Construction of ABC Building
- ❖ Contract Sum LKR : Rs. 600,000,000.00
- ❖ General Condition of Contract: CIDA/SBD/02
- ❖ The Employer : A Government Organization

- ❖ The Contractor : C1 Grade Contractor
- ❖ The Engineer : A Government Organization
- ❖ Duration (Months) : 18
- ❖ Commencement : 21st September 2016
- ❖ Schedule date of Completion :19th March 2018

1st EOT granted : Up to 19.05.2018 (Due to contractual problems on piling works and insufficient space at the site) on 23.07.2017

The Employer requested the Engineer to check the possibility of adding an extra floor to the Millennium building at ABC hospital on 21st May 2018. Since, the land was very much limited at the hospital. The Engineer confirms to the director, the possibility of adding another floor on 23rd May 2018. Finally, the Employer decided to have the additional floor in the ongoing building which the Contractor agreed to carry out as a Variation.

MOU for constructing an additional floor in the Millennium building to accommodating

A urology unit is signed by the secretary and donor on 09th October 2018 and approved the Cost Estimate amount of Rs.35,422,834.83 for this additional floor.

The Contractor was instructed to commence the work on the additional floor (7th floor) on 30th March 2019 and the Engineer instructs the Contractor to submit a revised program for the completion of the project by 31st October 2020

- ❖ Status of the project : Successfully Completed
- ❖ Actual completion :31st October 2020

Certain works had to be temporally suspended/decelerated to which Contractor had additional claims (Prolongation claims).

Impact on the Quality of the building

Since the decision to have an additional floor was taken after the 50% of the structure was completed, some safety factors had to be compromised (reduced) to an acceptable level.

4.2.3 Respondents of Interviews

The sample for this study consisted of 16 construction experts with experience in public building projects. In addition, for each case, four number respondents were interviewed, with the group consisting of experts associated with the projects as well as experts who were not involved with the project. The details of the respondents are as follows;

Table 4.2: Respondents of Interviews

No	Case Code	Respondents Code	Experience in Construction Industry	Experience in Public Building Construction Projects	Involved with the relevant Project subjected to the Case
1	CS. A	R1	20	10	Involved
2		R2	17	10	Involved
3		R3	12	8	Not Involved
4		R4	8	5	Involved
5	CS. B	R5	15	10	Involved
6		R6	10	8	Involved
7		R7	8	6	Not Involved
8		R8	8	5	Involved
9	CS. C	R9	16	11	Involved
10		R10	12	10	Involved
11		R11	10	7	Not Involved
12		R12	9	7	Involved
13	CS. D	R13	18	13	Involved
14		R14	15	11	Involved
15		R15	12	10	Involved
16		R16	7	5	Not Involved

As previously stated, respondents were chosen based on their key experience in the field of public building construction, and respondents who were directly involved in the project were chosen to acquire the perspective of the specialists within the frame. Furthermore, persons who were not involved with the projects were chosen to provide a perspective from the outside of the frame.

4.2.4 Findings of Case Studies

The purpose of the case study analysis was to determine the specific causes for the indeterminacy of project scope in Sri Lankan public building projects. In addition, the data analysis of the case studies was used to determine techniques for minimising

scope changes. Furthermore, the respondents related to each case were subject to identify the impact on the Iron Triangle by each cause. The study's findings can be summarised as follows.

4.2.5 Causes for the indeterminacy of project scope

From the literature review, several causes were identified and taken through to the data analysis. The discovered causes, on the other hand, were subject to scope changes in general construction projects and not to the indeterminacy of project scope in public building projects. As a result of the case study analysis, the reasons for scope changes in public building projects in Sri Lanka were revealed. The causes of each instance were found and analysed in the form of bellows. However, for each case, **the causes stated by three or more respondents were chosen as the true causes for the scope changes.**

Table 4.3: Causes for the indeterminacy of project scope

No	Causes for Scope Changes	CS. A	CS. B	CS. C	CS. D
Causes derived from Literature Review	Project Priority	√	√	√	√
	Lack of Motivation and Decision	√	√	√	√
	impractical design	√	√	√	√
	labour shortages				
	Project Risk			√	
	Quality Issue				√
	Lower Productivity				
	Failure to reach customer expectations	√	√	√	
	Poor effort estimation	√			
	Less effort on defining scope		√		
	Slow down project Progress				
	Poor performance				√
	Unforeseen conditions			√	
	Technological uncertainty	√			
	Unclear scope	√	√	√	√
	Change Cost		√		
	Limited Project Resources				
	Error generation rate				
	Poorly written scope		√	√	
	Effort wasted				
	Project Failure				
	Lack of Clarity	√			
	Scopes may be ambiguous	√		√	
	Changes in Legislations		√		
	Changes in regulation		√	√	
	Client Change	√	√	√	

No	Causes for Scope Changes	CS. A	CS. B	CS. C	CS. D
	Rework				
	Delays in Schedules				
	Lack of Concentrate on defining scope	√	√	√	√
	Communication and Coordination Gaps	√			
New Causes Identified from Interviews	Lack of end-user inputs during the design stage	√	√		
	poor coordination between the other relevant authorities	√			√
	Design deficiencies	√	√	√	√
	Poor Decision Making	√			√
	Lack of Planning	√	√	√	√
	Political Influences	√	√		

Causes for Scope Changes – Based on CS. A

According to the situation, the Contractor was fulfilling his obligations, and the additional work had been added based on the Employer's request. One of the key causes for scope changes in this scenario was a *Lack of Concentrate on defining scope*. The Employer and the consultant were not taken adequate responsibility for the project during the pre-contract stage in defining the project scope. Therefore, its makes lot of changes to the project during the implementation stage as demonstrated by Case CS. A.

In addition to that, in the given scenario, one of the main sources of project scope indeterminacy is *Impractical Designs*. The scope of the project was changed as a result of the client's impractical designs, and it was incorporated as additional work for the project. In this situation, the project's time duration and overall budget were increased, which had a significant impact on the project's Iron Triangle and which was accepted by all respondents in the interviewee poll in CS A.

Furthermore, Interviewees R1 to R4 also indicated *Failure to reach Customer Expectations* as a cause for the case, and this cause might be considered one of the scenario's base causes. The whole additional work was implemented due to the end user's expectations not being met. As a result, scope change occurred, affecting the project's Iron Triangle. Further, the client's party also had not recognised the necessity for an upgrade to the access road in the provided circumstance due to above cause. As

a result, the Client added the development of the access road to the scope as an additional task as it had not been prioritised during the tendering process.

Moreover, Respondents R2 and R3 noted that a *Lack of Clarity* is another important source of project scope indeterminacy as the Client's work with their consultant team had not been fully finalised the scope when the time of the Contract award. Due to the above problem, the client proposed several changes and added them to the scope as additional works. According to Interviewee R2, for example, cafeteria rooms are frequently included in these types of designs. Due to a lack of clarity in the defining scope, the customer had overlooked that aspect. As a result, one of the primary additional activities for the scope resulted from the lack of clarity in defining the scope.

Furthermore, Respondents R2, R3, and R4 stated that *Political Influences* as well as *Communication and Coordination Gaps*, may have contributed to the adjustments made throughout the implementation stage. The 26 Numbers retail shops and grocery stores would not have been missed during the defining scope if the Employer had paid more attention to it. As a result, the respondents hypothesised that it would be a key cause of scope indeterminacy in the current case.

Furthermore, there are several causes that have a slight impact on the given scenario, and at least two respondents from the sample suggested them. *Lack of Motivation and Decision, Poor Effort Estimation, Ambiguous Scopes, and Client Change* were the causes that had a slight impact on the given case. Though these causes are not the primary causes for the provided case, the respondents considered that the aforementioned causes had a significant impact on the CS project scope, and that these causes may contribute to project scope indeterminacy in all general public building projects.

In addition, several critical reasons that were unique to the situation were discovered. Respondents who were part of the project stated the above-mentioned additional causes of the case. Three major causes suggested by the respondents were a *Lack of End-user inputs during the design stage, Poor Coordination between the other relevant authorities*, and *Design Deficiencies*, and respondents explained that a several issues arose as a result of coordination problems with the relevant authorities and

issues in end-user outputs. In addition, the respondents' perspectives yielded two more significant causes: *Poor decision-making* and *Lack of planning*.

However, based on the responses of respondents R1 to R4, 17 causes for project scope indeterminacy in Sri Lankan public building projects were identified, including five novel causes.

Causes for Scope Changes – Based on CS. B

Based on CS B, the Contractor was fulfilling his obligation and new additional works had been added by the Employer to the original scope of the project. The fundamental reason for scope indeterminacy is, first and foremost, to improve the quality of the building due to *Failure to reach the customer expectations*. Respondents R5 to R8 suggested that giving adequate concentrate on defining scope at the design stage will always ensure the expectations of customers and minimise the impact of scope changes.

According to the respondents R6, R8 and R9, according to the Planning and Building Regulations for apartment houses in the Colombo area, each unit must have its own parking place if it is larger than 70 square metres, while units smaller than 70 square metres shall give one parking slot for two housing units. The designer had fulfilled the design regulation according to the Employer's requirement (ER); however, it did not comply with the practical scenario as most of the targeted client has one or more cars per housing unit. In this situation, the Employer decided to change the scope of the project though it has complied with planning and building regulations, thus it was added to the scope as an additional work item. As a result, the project scope was changed and carried out as an add-on task, adding time and cost to the overall project to reach the customer expectation and also to improve the quality of the building.

Furthermore, *Changes in the Regulations* as noted by respondents R5 to R8, and further, based on the expert comments, the regulations have been modified in 2021 after 2008. Therefore, it is possible to emphasize the value of updating regulations on a regular basis (e.g., every 5 years) in accordance with the country's development strategy. Therefore, modifications to regulations were identified as the primary source of the scope indeterminacy in public building projects. Hence, regulation changes have

the same impact as indicated above, and they can be considered a key cause of scope indeterminacy in the Sri Lankan context.

Furthermore, according to respondents R5 and R6, *Client Change* is a distinct cause that can be established here. The project's procurement process has been completed in late December of 2014 and the contract has been awarded in same period. However, January 2015 has been established a new government and they temporary suspended the project more than for one and half year period. The Employer had changed in this situation since the political demotivation and it was affected by the contract. Based on this situation the Contractor raised disputes and referred to DAB and requested price escalation for the extended period. Hence, this scenario has affected the Iron Triangle performances.

Furthermore, according to respondents R5 and R6, a *lack of concentration on defining scope* always leads to scope changes. In this case, the client had been focused on the additional costs associated with extended Preliminaries. Hence, the Employer and the Design and Built Contractor are solely responsible for establishing scope with sufficient concentration, and if the Employer identifies their tasks and requirement correctly, there is a chance of avoiding scope changes in public building projects.

Additionally, four number new causes were identified uniquely to the Case. *Lack of end-user inputs during the design stage* and *Design deficiencies* were two major causes that can be related to the given scenario. The swimming pool had been added as a fresh additional work for the scope. If the Employer and the Design and Built Contractor had focused on the end-user opinions and design deficiencies, these scope changes would have been avoided. In addition to the above, due to the changes in the government, some political influences occurred in this project and it also led to a scope change in the given scenario. Therefore, it is another situational cause for scope indeterminacy in public projects in Sri Lanka. Finally, lack of planning is another key cause in the Case which has led to the scope indeterminacy in public building project.

Moreover, A total of four new causes were discovered as being specific to the Case. *Lack of end-user inputs during the design stage* and *Design deficiencies* were two key causes that could be linked to the situation. The swimming pool was introduced as a

new addition to the scope of work and these changes may have been avoided if the Employer had focused on end-user feedbacks and design flaws precisely. In addition to that, according to responders R6 and R7, a *lack of planning* can be considered a scope indeterminacy in this circumstance and can be a reason for Public Building Construction projects.

Finally, 14 reasons unique to Case CS B were discovered, including four new unique causes. The results were based on the opinions of expert respondents R5 to R8.

Causes for Scope Changes – Based on CS. C

The event in Case CS. C was caused by a change in project scope due to complications with implementing agencies and a delay in the start of work. *Project Priority*, according to responders R9 to R12, is a significant reason for the delays created by the Employer. The scope was amended and began after 21 months from the intended date due to project delays and land acquisition issues. The project would have been completed on the contract's stated day if the implementing agency had put priority on reducing the delay. Furthermore, the project's prioritisation resulted in significant delays and scope indeterminacy.

Furthermore, the respondents R9 to R12 further stated that the slow down project progress and poor performance due to *unforeseen conditions* are the main sources of project scope changes. Furthermore, the respondents mentioned that, *project risk* due to governmental and *legislation changes* have been affected by these scope change. R9 to R12 respondents further stated *Poor decision-making* of the relevant parties towards the project, was the reason for the reduced number of houses in the amended scope. As a result, the respondents strongly agreed that a *lack of desire and decision-making* would have a significant impact on the scope changes in the scenario.

Respondents R9, R10, and R11 also suggested that the *Impractical drawings* had a similar influence on the scope changes. At the time of the tender offer, the Contractor was supposed to start the work with a several confusing issues about the drawings. The ambiguous drawings were caused by the fact that site employees with full competence by the contract were not assigned. At the construction site, only one Engineer had been assigned as Construction Manager. All other engineers have one or two years of

experience, whereas it required ten and five years of expertise. In another hand, there was no engineer on-site with piling experience. As a result, the project scope uncertainty was significantly impacted by *Impractical Drawings*.

Another driver of project scope, according to responders R9 and R11, is *Project risk*. As stated in the case description CS. C, there were unforeseen factors that caused the project to be delayed. Due to the *unforeseeable circumstances* of the event such as the change of the funding agency by the government, several concerns arose in this case. As a result, the Implementation Agency was unable to devote their full attention to the project as a project risk had derived from the unavoidable conditions. Therefore, authorities were able to make scope changes to the project and make it practical.

In addition to that, two or more respondents highlighted the causes; *Unclear, Scope may be ambiguous* and *poorly written scope*, which have an average impact on the scope changes that occurred in the case. Respondents also stated that these causes have a significant impact on every public building project regarding the scope changes.

The government had appointed new authority for the project due to the excessive delay, therefore *regulations changes* and *client changes* were two more key causes of the presented circumstance. Respondent R9, on the other hand, strongly agreed that this was one of the most unique variables contributing to the indeterminacy of the project scope in this scenario. The respondent strongly believed that this was the primary reason for the authority's decision to reduce the number of housing units in this project based on the financial issues

Additionally, Respondents R9, R10, and R12 noted that a *lack of concentration on defining scope*, as well as *communication and coordination gaps*, may have contributed to the scope changes of the project. The scope would have changed if the necessary authorities had come out with the acquisition issues at the time of the tender. As a result, respondents expected that it would be a major factor of scope indeterminacy in the given case CS. C.

Finally *Design deficiencies* and *Lack of Planning* were derived as new causes for the given scenario of the case and respondents R10 and R11 strongly believed it had a significant impact on the scope indeterminacy in this project.

To conclude, 14 reasons unique to Case CS C were discovered, including two new unique causes. All of the results were based on the opinions of expert respondents R9 to R12.

Causes for Scope Changes – Based on CS. D

As stated in the case description, an additional floor had been added to the project, which has resulted in scope changes in this particular circumstance. Due to the limited area on the land, the floor was built, and these difficulties should have been addressed at the feasibility stage. As a result, according to responders R13 to R16, these changes have occurred as a result of a *low priority* given to defining scope at the feasible stage, and this is a significant factor for scope changes in this project.

Furthermore, due to the client being unable to submit the required drawings linked to the additional floor implemented, *impractical designs* played a critical role in this scope indeterminacy. As a result of this consequence, some quality assurance was reduced as the Contractor had to compromise some project safety elements.

Furthermore, respondents said that the project's scope changed after the first half of the construction was completed. According to respondents R13 and R15, a significant source of project scope change delay is a *lack of motivation and decision*. The addition of a new floor to the modified scope was due to the poor decision-making of the relevant Organisation on the project. As a result, the majority of respondents believed that a lack of motivation and decision-making would have a substantial impact on scope changes in the scenario.

Furthermore, the client had delayed certain works due to quality difficulties with the continuing construction work. At the time of construction, the Contractor had also claimed halted work. As a result, it can be concluded that scope changes may occur as a result of project quality difficulties, and the statement was strongly approved by respondents R15 and R16 to the given scenario.

Furthermore, due to the client's *poor performance* on this project, work was suspended after 50% of the job was completed. According to expert R13 reported that the client

did not manage a proper performance check during the project through the consultant team.

According to respondent R16, a *Lack of Concentrate on defining scope*, is aligned with the project priority. As a result, the factors considered in the project priorities should be stated here, and the defining scope with a proper concentration plays a vital role in every construction project. As a result, in this situation, the client bears sole responsibility for scope definition with a correct focus, and the changes had occurred due to the flaws in the above-mentioned reason of the given scenario.

In addition to that, poor coordination between the other relevant authorities, *Design deficiencies*, *Poor Decision Making*, and *Lack of Planning* can be highlighted as new causes for the given scenario and it has a significant impact on the changes in project scope in Public Building projects.

Finally, 11 reasons unique to Case CS D were discovered, including four new causes. All of the results were based on the opinions of expert respondents R13 to R16.

To summarise, the case study analysis highlighted the causes of scope indeterminacy in public building projects. According to a literature review, 30 different causes for scope changes were identified in general construction projects. On the other hand, the respondents to the case study analysis were in favour of verifying the causes of the public building projects in Sri Lanka. In addition, respondents suggested new reasons to be added to each case, resulting in a total of 27 causes related to public building projects, including six new causes, discovered as a consequence of the case study analysis. Furthermore, there are several common causes for public building projects that were suggested by 75% of all respondents, and the other factors may have both common and distinctive impacts on the given scenarios. The entire causes of scope changes discovered from the case study analysis are depicted in the diagram below (Refer Figure 4.1).

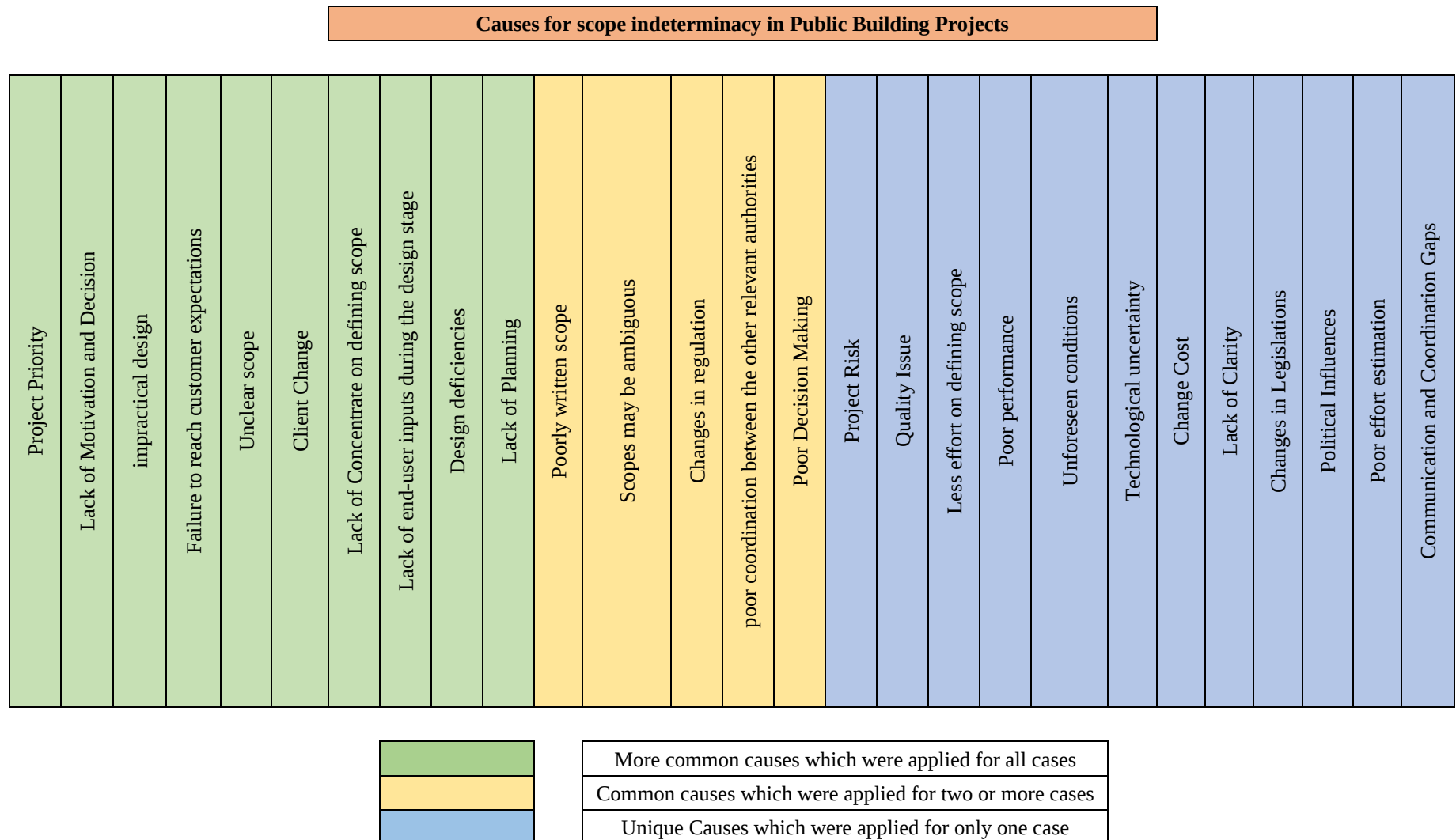


Figure 4.1: Causes for Scope Indeterminacy

4.2.6 Management Strategies for reducing causes of project scope indeterminacy

From the literature review, several Management Strategies were discovered and taken through to the data analysis. The discovered strategies, on the other hand, were subject to minimise scope changes in general construction projects and not to the indeterminacy of project scope in public building projects. As a result of the case study analysis, the most prominent strategies for reducing scope changes in public building projects in Sri Lanka were revealed. The causes of each instance were found and analysed in the form of bellows. However, for each case, **the strategies stated by three or more respondents were chosen as the true prominent strategies for the scope changes.**

Table 4.4: Management Strategies for reducing Scope indeterminacy

No	Strategies to Minimise Scope Changes	CS. A	CS. B	CS. C	CS. D
1	Identify requirements properly	√	√	√	√
2	Identify Stakeholders				
3	Identify Project Drivers	√	√	√	√
4	Examine the Scope Statement				
5	Queueing Theory - reducing the impact of waiting periods on critical work packages				
6	Considerations of time			√	
7	Communicate what to do and how to deliver the results at the initial stage	√	√	√	√
8	Identify both activities and results				
9	Consolidate requirements			√	√
10	Consideration of budget	√			
11	Complete prevention of a scope				
12	the project manager needs to be vigilant				
13	Facilitate the assignment of roles and responsibilities			√	
14	Avoid the omission of tasks and their duplicity				√
15	Guide the realization of both budget and schedule				
16	Document learned lessons		√		
17	Reference improvement processes				
18	understand the client's vision properly	√	√	√	√
19	Be unambiguous	√	√	√	√
20	Be accurate	√	√	√	√
21	Take both preventive and corrective actions	√	√	√	√
22	Analyses requested changes impact, studying its conditions and traceability	√			√
23	Influence factors that cause scope changes				
24	Prescriptions for client change.	√	√	√	√
25	Prescriptions for unforeseen risks	√	√	√	√
26	Prescriptions for unclear scope	√	√	√	√
27	Define both work and deliverables				

No	Strategies to Minimise Scope Changes	CS. A	CS. B	CS. C	CS. D
28	Analyses requirements providers				
29	The study agreed on requirements impact				
30	Examine assumptions and constraints		√		√
31	Consideration of specification	√	√	√	√
32	Consideration of customer satisfaction	√	√	√	√
33	Maintaining the status quo within the organization.				
34	Include both intermediate and final deliverables characteristics, specifications and acceptance criteria, preliminary cost estimates, and schedule milestones				
35	Integrate changes control				
36	Facilitate impact analysis and communication				
37	Measure performance	√			√
38	Identify variations				
39	Get a formal acceptance				
40	Review deliverables	√	√	√	√
41	Ensure agreed changes are properly processed by the Employer				
42	Well defined policies and guidelines	√			
43	Clear Client Brief	√			
44	Design the project after a detailed feasibility study	√			
45	Proper communication between the designer, shareholder/ End-users and the Employer/developer	√			
46	Design coordination- Architectural, structural, services, landscape	√			
47	Incorporate authority requirements at the design stage	√			
48	Identify and include correct service provisions at the design stage	√			
49	Identify the requirement of end-user properly		√		
50	Follow the regulations Up date of development regulations		√		
51	Propose the completed finalised design at the Bidding stage		√		
52	Reduce the impact of political influences by the Government institutions relevant parties		√	√	
53	Analyse the project scope with the budget allocation properly			√	

Case CS. A – Most Prominent Management Strategies to minimise scope project scope indeterminacy

According to the case, respondents R1 to R3 supported that the additional work was added as a result of scope changes, and the duration and cost of the project increased. These changes may have been avoided or minimised in this case if the Employer had taken the necessary procedures to *identify the requirements properly*. Construction of

26 retail and supermarket stores, construction of 08 cafeteria spaces, access road improvements to the mbuilding project, and a chain-link fence around the boundary wall with a chain-link swing gate were among the changes. The amount of work is substantial, and the client's requirements were misled at the project's early stages. As a result, the changes to the scope were treated as new extra work. Therefore, the scope changes had been done to the original scope as new additional works. Hence, it's the foremost duty to identify requirements properly in a project to minimise the scope indeterminacy types of issues.

Furthermore, in this scenario, R1, R2 and R3 stated, that the subsequent modifications could have been avoided if the early stage had included *communicating what to do and how to deliver the results*. Respondent R3 also mentioned that this strategy is also linked to the topic of appropriately identifying requirements. The feasibility stage is crucial in the construction process since it is during this stage that the scope of the project should be correctly defined. As a result, engagement with stakeholders is critical at this stage to accurately identify the requirement and avoid scope indeterminacy in the future.

Moreover, another important method that may be applied in this case is the *consideration of the budget*. According to respondents R1 to R4, the entire budget had increased by a significant amount to the final contract sum. Therefore, if the customer could afford to allocate such a budget, the scope could have expanded appropriately at the outset to minimise indeterminacy. In this example, respondent R2 noted that if the consultant team had been informed about the client's budget allocation at the time of the scope was finalised, these supplementary works would have been added at that stage. As a result, taking the budget into account will always make it easier for the Employer to get his desired outcomes within the level of expectations.

In addition, *analysing the impact of requested changes, evaluating their conditions, and ensuring traceability* are important methods employed in this project to mitigate the impact of scope indeterminacy. According to R1, the person in charge of a substantial portion of the original project, analysing the desired modification impact of this project helped to avoid a lot of negative impacts that could have been caused

by scope changes. Therefore, it is a well-known solution for this situation, and it can also be used to reduce scope indeterminacy in public-sector construction projects.

Furthermore, another important method for dealing with scope indeterminacy is the *consideration of specifications*. According to respondents R2 and R3, the chain-link fence surrounding the boundary would have been noticed early and added to the scope without any changes if the designers had worked together on the specifications. As a result, these specifications are critical to the project scope to minimise changes during construction. One of the major faults of today's public building project scope indeterminacy, according to respondents R1 to R4, is not paying enough attention to the project specifications. A massive number of scope changes in public building projects have occurred as a result of this error. As a result, it can be proved that this is one of the most important management tactics for reducing scope indeterminacy in these types of projects.

Moreover, respondents R2 and R4 recommended that *assessing deliverables* early on reduces the impact of scope changes by drafting a clear explanation of the client's needs. This project may have benefited from the above-mentioned method, which would have decreased the impact of increased cost and time owing to the additional work.

In addition, respondents R1 to R4 devised a variety of innovative solutions for the scenario to lessen scope indeterminacy in these types of projects. One of the key strategies proposed by the respondents is *well-defined policies and guidelines*. Providing guidelines can help to mitigate the impact that scope changes due to additional work and ensure the project's development. Furthermore, the policies guarantee the contractual parties' obligations regarding the indeterminacy of project scopes. As a result, it is the responsibility of the appropriate authorities to establish updated guidelines and rules addressing project scope indeterminacy to avoid future problems.

In addition to that, R1, R2, R3 stated another crucial element to consider in these types of projects is a *clear client brief*. Providing a clear client brief is also subjected to appropriately identifying requirements at the outset. Furthermore, respondent R2 noted

that the client brief should be finalised with comprehensive drawings before the building work begins. Respondent R3 elaborated on the preceding remark, stating that delay issuing drawings and instructions were subjected to the scope changes. As a result, drawings and Employer's requirement are crucial components of construction projects that must be prioritised to minimise costly changes to the project scope.

Similarly, respondents R2 and R3 also emphasised the importance of doing a thorough *detailed feasibility analysis* to mitigate the impact of scope changes. Respondents stated that feasibility studies have become more challenging in recent years as a result of a lack of attention to detail in preparation. The project design is also affected by the aforementioned factors, as the design must be completed to conduct a full feasibility analysis. Therefore, it is the Employer's primary responsibility to do a thorough feasibility analysis to minimise the indeterminacy of the project scope.

In addition to the case, the respondents also suggested new strategies which can be used to manage the scope indeterminacy of the public building projects. *Proper communication between the designer, shareholder/ End-users and the Employer/developer* will ensure the resolution of any future scope issues that may arise during the construction process.

Moreover, the majority of scope changes are hampered by the inability to obtain sufficient requirements from key authorities at the time of scope design. Therefore, *incorporating authority requirements at the design stage* is another management strategy that will also secure the project and reduce the impact of scope indeterminacy of the public building projects.

Furthermore, *Identifying and Including correct service provisions* at the design stage can improve the efficiency of project progress and reduce the harm to the project scope that can be occurred due to the specification errors in the project. Therefore, it can be used as another key management strategy and reduce the impact of scope changes.

More than all above, the respondents R1 to R4 also stated several common management strategies to reduce the scope indeterminacy in the public building projects. *Identify Project Drivers, being unambiguous, being accurate and taking both preventive and corrective actions* are some of the common management strategies to

reduce the scope indeterminacy of public building projects. These tactics should be implemented at the start of the project and have a significant impact on maintaining a stable scope with no changes.

Further, *Prescriptions for client change.*, *Prescriptions for unforeseen risks and Prescriptions for unclear scope* are some predictive strategies that can be used to reduce the impact of scope changes in public building projects.

Finally, *Measure performance* is another key strategy that should be implemented continually throughout the project to reduce scope changes in public building projects

Taking into account all of the aforementioned management tactics, 22 strategies for minimising scope changes in public building projects were discovered and implementing these strategies will always ensure that the influence to the Iron Triangle is minimised.

Case CS. B – Most Prominent Management Strategies to minimise project scope indeterminacy

Based on the findings of the case study, respondents R5 to R8 stated that adequately *identifying the requirement properly* is also a key management strategy in this circumstance to reduce the impact of scope changes. A swimming pool for the complex had been added to the scope as an additional development. If one *understands the client's vision properly and correctly* recognised the requirement, extra work no longer falls under the additional work category and instead comes under the original contract. As a result of the competent inability of Employer and Design Built Contractor to complete this assignment, the scope was changed. According to the respondents' perspectives, changes can be reduced by paying close attention to the requirements precisely.

Furthermore, another essential management method proposed by respondents R6 and R7 is to *communicate what to do and how to deliver the results*. It is pre-required to identify prospective buyers' needs and include those requirements in the scope of work. Further It will help to deliver expected product to the targeted group. Therefore, it directly affects to minimise the project scope indeterminacy. Even though, the

Employer has increased the quality of buildings through scope changes, needs to decide on the quality improvement at the early stage of the construction. However, as the Employer was unable to do it at the design stage, it resulted in the creation of an additional budget to the original scope. Further, the respondents strongly asserted that *analyse the project scope with the budget allocation properly* these risks can be reduced through the Employer's identification of the final budget allocation to the project and the effective communication between the parties.

Moreover, *document learning lessons* are linked to the above-mentioned strategy as it is a pre-requirement to include the previous experience in the new project and the Employer can reduce unnecessary cost implications to the project. If the Employer can identify the need for changes to the regulation can provide provisions in the early stage of the project. As a result, document learning lessons will ensure that the design is accurate and compliant with the rules and regulations. Therefore, this technique can be used as an effective management strategy in Sri Lankan public building projects.

According to the circumstances of the case, the tendering procedures and approval process of the initial documentation work began in late 2014. However, with a new government in place, the project was initiated in 2015. In this case, the respondents R5 and R6 concluded that, due to government changes, new government temporary suspended the project more than for one and half year period. As a result, the Contractor requested price escalation for the project. Therefore, respondents stated that to mitigate the impact of scope changes, early *prescriptions for client change* might be used as a useful management technique in this study. According to respondent R6, these types of challenges have resulted in significant changes in project scope. Hence, the responder strongly asserted that if this technique is implemented effectively for upcoming public-sector building projects, it would be able to avoid several scope changes in projects as a result of government changes in the future.

Furthermore, if working on a public building project with a design and built project, the Contractor's party has the fully responsibility to ensure that the project is in strict compliance with building and planning regulations to the design. However, if the Contractor party becomes aware of this type of problem, the Contractor will be unable

to amend the contract as the client has exclusive responsibility for changing the scope. As a result, respondents R7 and R8 highlighted that to address these scope issues, Contractors should *have prescriptions for unclear scope*. In addition to that, respondent R7 noted that this management strategy can be applied to projects that are started with incomplete designs. To avoid the consequences of scope indeterminacy, Contractors can have prescriptions for ambiguous scope if the Employer's requirement statement are incomplete. Hence, this is an important management strategy that can help the Contractor avoid negative consequences as a result of scope changes.

Moreover, another important method for dealing with scope changes in public building projects is to *consider the specifications*. Respondents R5 and R8 asserted that the disagreement could have been avoided if the specification was properly considered by the parties to the contract. Even though, the project scope had been changed, the Employer had not accounted for prolongation cost for the extended preliminaries since the new government temporary suspended the project more than one and half year period.

In addition to the management strategies discovered through the literature study, respondents proposed several novel tactics for minimising the impact of project scope changes in public building projects. *Accurately identifying end-user requirements* is a significant management strategy that is highlighted by respondent R5, R7 and R8. If the design and build Contractor identified the end-user requirements in early stage, the Employer would not have ignored the car parks and additional balcony places at the design stage. As a result, paying close attention to the need of the end-user is one of the most important strategies in public building projects, as it has a significant impact on reducing scope changes in ongoing projects.

In addition to that, respondent R5 and R7 said that the design had not been fully finalised at the time of the project's start. The scope change that happened in the scenario, according to the responders, were due to the lack of full designs at the start of construction. As a result, the respondent suggested that *submitting the completed finalised design during the bidding stage* will help to reduce these types of problems in public building projects.

As previously stated, the project suffered some consequences as a result of the government transition. Therefore, these political roadblocks had a considerable impact on scope changes, particularly in Public Building Construction projects. Hence, *reducing the impact of political pressures by relevant government institutions* will always lower the scope impact of these types of projects due to political issues.

Further, respondents also suggested some of the common strategies which can be applied to the public building projects. *Identify Project Drivers, being unambiguous, being accurate and taking both preventive and corrective actions* are some of the common strategies that can be used as management tactics in the initial design stages of the project to reduce the impact of scope changes during the construction stage.

Moreover, *Prescriptions for unforeseen risks, examining assumptions and constraints and Consideration of customer satisfaction* are three more frequent strategies that Contractors might employ to keep scope changes in public building projects to a minimum.

Accordingly, 19 strategies were discovered connected to public building projects, including four new tactics, after considering all of the above methods, and the overall result was based on the thorough responses provided by Respondents R5 to R8 in case CS. B.

Case CS. C – Most Prominent Management Strategies to minimise project scope indeterminacy

As in earlier situations, *identifying requirement properly* is an important management approach in case CS. C as well. Respondents R9 and R10 responded that in the provided scenario, even if the project was planned to build 1000 dwellings, the requirement should have to be changed owing to acquisition and financial challenges. Therefore, it should have been discovered during the feasibility study, and the competent project implementation party should have assessed the right requirement identification. In these types of public construction, if the Employer's requirement is done correctly, there is a low chance of scope changes.

Further, *identifying project drivers* is also an important management strategy for public building construction projects in the given context. Respondents R9 and R12 agreed with the preceding remark, stating that throughout the driver identification phase, the client of the scenario might have come up with acquisition and financial difficulties before finalising the design. The goal of recognising these drivers is to help the Employer to decrease the risk and complete the project design promptly. The strong proposal offered by responder R10 indicated that these drives can also influence the project's scope indeterminacy during the construction period as well. Therefore, a thorough understanding of the project drivers allows the client to engage with scope changes and minimise their impact.

Time consideration is an important key approach that may have been implemented to lessen the impact of this case. The null duration had dragged out for a long time due to political concerns and unavoidable factors that transpired in the given scenario. Due to the prolonged void period, the client was responsible for the costs of damages incurred as a result of contract restructuring and scope change. Respondent R11 argued that if the implementing agency had given more attention to managing this null period, the impact of the scope indeterminacy would have been greatly lessened compared to the situation at the time. As a result, respondents strongly suggested that project schedule planning is a good management method when dealing with the indeterminacy of project scope in public building projects.

Poor coordination and communication between the parties and the interrelationship with necessary authorities regarding the issues had a significant impact on the breadth of the scenario. In this scenario, poor relationship between the other government institutions for communicating with all parties involved in the contract to address the issues and take safeguards. The Employer, on the other hand, had not taken the essential efforts to communicate what needed to be done and how the project should be completed. As a result, R10, R11, and R12 stated that the most effective management method to avoid the effects of scope indeterminacy is to *communicate what to do and how to deliver the results in the initial stage*.

Moreover, according to respondent R10, *consolidating the requirements* guarantees that the project design meets the client's expectations. The stated scenario necessitates the construction of 1000 dwellings. However, the authority could have integrated the requirement with the available challenges and unavoidable situations in the feasibility study at that time. In that instance, the client would have to make a firm decision that the current project drivers are insufficient to complete the task and could have to postpone the tendering process for some time until the issues are resolved. Due to the client's failure to consolidate requirements, the scope was amended after the contract was awarded.

Further, respondent R10 stated, that at the initial stage, the client must have a sense of knowledge regarding the occurring acquisition process of the land. On the other hand, the client's funding concerns and budget allocation should be a well-known consideration at the initial stage. If the client has not fully discovered the details of the two concerns described above, it is the client's primary responsibility to maintain some prescriptions in case future risks arise as a result of these issues. It will make it easier for the client to deal with issues, particularly when it comes to scope changes. However, as the client was unable to meet those requirements in the current scenario, based on the situation forced to deal with the issues after the contract was awarded and re-adjust the scope. As a result, *perceptions of unforeseen risks* are an important management tool for reducing scope indeterminacy in public building projects.

In addition to the previously mentioned strategies, the responders proposed new strategies that are in line with the scenario. Due to the influence of political concerns on the project, it has been delayed. These issues can be mitigated by *reducing the impact of political influences* to the public institutions. As a result, careful consideration management technique shall be applied for public-building projects to deal with scope indeterminacy.

Furthermore, *Analyse the project scope with the budget allocation properly* is another key strategy for the above scenario. Analysing the budget and scope of the project always guarantees that the project delivery is achievable. As a result, no scope changes will be made during the construction period.

Moreover, respondents also suggested some of the common strategies which can be applied to public building projects. *Understanding the client's vision properly, being unambiguous, being accurate and taking both preventive and corrective actions* are some of the common strategies that can be used as management tactics in the initial design stages of the project to reduce the impact of scope changes during the construction stage. Further, *Prescriptions for client change, Prescriptions for unclear scope, Consideration of specification, Consideration of customer satisfaction, and Review deliverables* are other common tactics used by Contractors to reduce scope changes in public building projects to a minimum.

Accordingly, 17 strategies were discovered connected to public building projects, including two new tactics, after considering all of the above methods, and the overall result was based on the thorough responses provided by Respondents R9 to R12 in case CS. C.

Case CS. D – Most Prominent Management Strategies to minimise scope project scope indeterminacy

According to respondents R13 to R16, the additional floor was implemented in the provided case since the requirement had not been effectively identified at the outset. If the customer had conducted a thorough feasibility analysis at the initial stage, the paucity of land would have been noted, and scope changes would have been avoided by adding the new floor when the design was finalised. The requirement identification, on the other hand, did not go as planned, resulting in scope indeterminacy in the project after 50% completion. As a result, to mitigate the impact of scope changes, proper *requirement identification* is critical in scope management.

As previously stated, discussions held during the early stages of a construction project have a considerable impact on the scope of the project. Unavoidable scope changes occurred as a result of the lack of discussion about the site's restricted land resources in the provided circumstance. As a result, according to respondents R13 and 14, *communicating what to do and how to deliver the outcomes early on* is a strong scope management method for dealing with scope indeterminacy in public building projects.

Furthermore, the challenge in the presented scenario was the scarcity of land. However, respondent R13 noted that the customer has to identify the problem early on and then combine the requirements based on the possibilities available at the time. The additional floor would not have been added to the design as a scope change if the requirement had been correctly consolidated at the design stage. However, after the project reached 50% completion, some of the work had to be halted due to a lack of coordination between the parties. As a result, *consolidating requirements* reduces the influence on project scope indeterminacy, allows for proper integration of needs, and allows for the optimal design at the design stage.

Respondents R14 and R15 reported that the scenario's scope changes came as an additional floor to the scope. However, as a result of this addition, some of the works were put on hold or omitted. In the above circumstance, R15 indicated that both addition works and omissions constitute scope changes. As a result, these omissions should be minimised to keep scope changes in public building projects to a minimum. As a result, *avoiding work omission and duplication* is an important management strategy for reducing the impact of scope indeterminacy.

Furthermore, respondent R13 indicated that, the client must be aware of the project's land scarcity difficulties before the construction start. On the other hand, if the land is limited, it is the responsibility of the client to discuss the additional tasks to be performed during the design stage. If the client has not fully understood the nuances of the two problems mentioned above, it is the primary duty of the client to keep some prescriptions on hand in case future unforeseen risks occur as a result of these issues. It will make dealing with concerns for the client easier, especially when it comes to scope changes. Hence, *perceptions of unforeseen risks* are an important management strategy for reducing scope change in public building projects.

Moreover, according to respondent R13, *measuring performance*, is an important management method for reducing scope indeterminacy in public building projects. If the consulting party had conducted a continuous performance check, the scarcity of land would have been discovered at the beginning of the construction process. Instead, the problem was discovered after the work had reached 50% completion. As a result,

establishing a *performance measure* in public building projects is a vital technique for avoiding scope indeterminacy. The respondent R16, on the other hand, contended that performance audits in public building projects are extremely infrequent these days since the authority has not given them the attention it deserves. Therefore, these roadblocks should be avoided, and performance should be managed carefully to avoid scope changes in future projects.

In addition to the aforementioned tactics, the respondent also mentioned other frequent strategies for public building construction projects. *Understanding the client's vision properly, being unambiguous, being accurate and taking both preventive and corrective actions* are some of the common strategies that can be used as management tactics in the initial design stages of the project to reduce the impact of scope changes during the construction stage. In addition to that, *identifying project Drivers, prescriptions for client change and prescriptions for unclear scope* are some common strategies that can be used for any public building projects towards the scope indeterminacy.

Based on the opinions given by Respondent R13 to R16, 18 management strategies were discovered related to the case and common public building projects to reduce the impact of scope changes.

There are several common management strategies for public building projects that were suggested by 75% of all respondents, and the other factors may have both common and distinctive impacts on the given scenarios. The entire strategies of scope changes discovered from the case study analysis are depicted in the diagram below (Refer Figure 4.2).

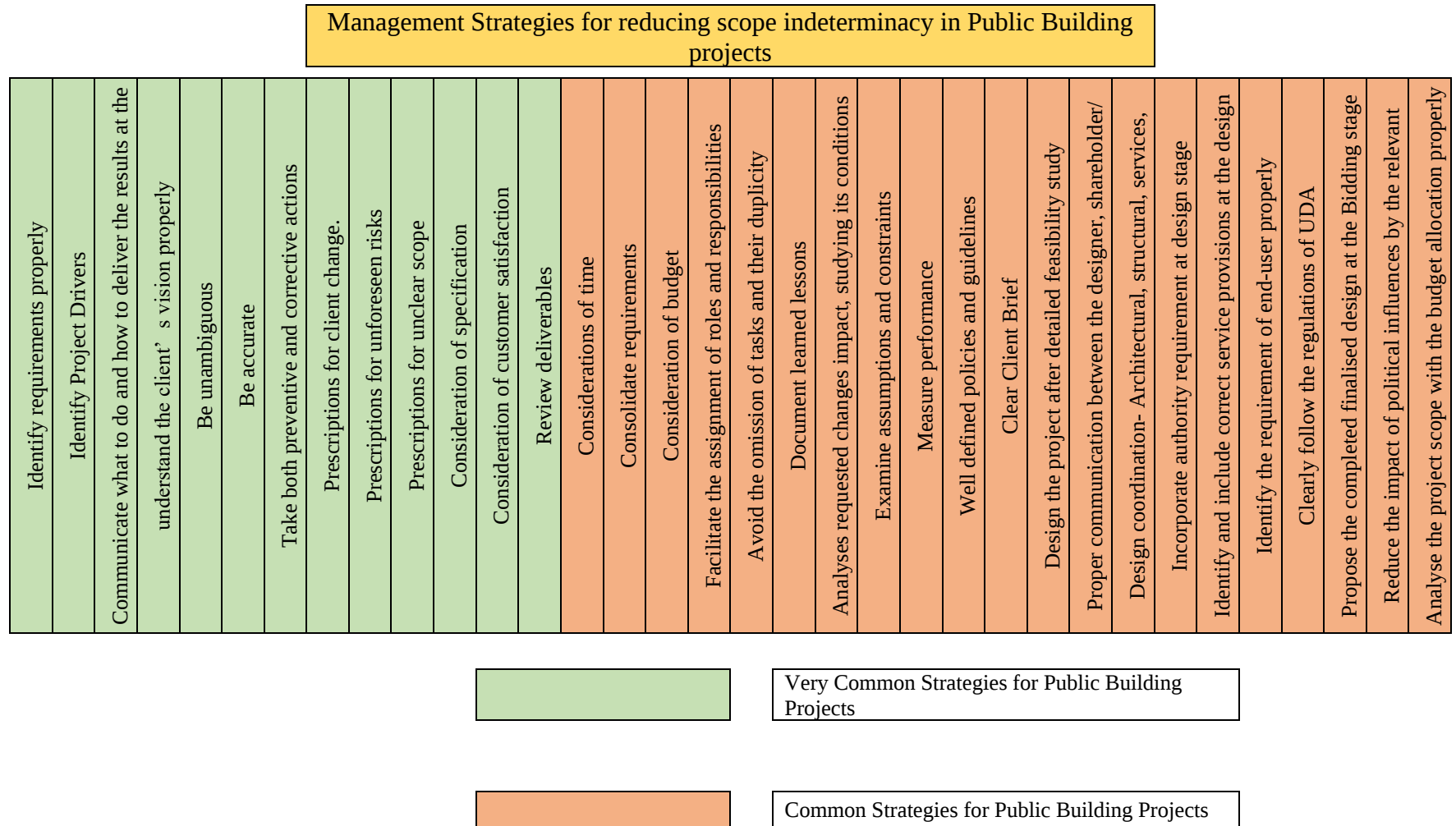


Figure 4.2: Management Strategies for reducing scope changes in Public Building Projects

4.3 Phase II – Questionnaire Survey

To achieve the fourth study objective, a questionnaire survey was conducted following the case studies analysis. One of the important aspects to address in the analysis is the impact of the causes on the Iron Triangle. During the first phase of the study, 27 reasons associated with public building projects were identified and analysed from the case studies. However, the next step is to determine the Iron Triangle's influence as a result of these factors, which was met by the questionnaire survey.

4.3.1 Objectives of Questionnaire Survey

The impact of the Iron Triangle on public building projects is a significant factor to consider in the study. In order to produce the deliverable successfully and efficiently, time, cost, and quality are the most important considerations in every construction project. The goal of a questionnaire survey is to identify the most effective reasons for the Iron Triangle and assess their influence on time, cost, and quality individually. As a result of the case study research, a questionnaire survey was conducted to discover the impact and crucial causes that have a substantial impact on the Iron Triangle.

4.3.2 Respondents of Questionnaire Survey

The major sample of the questionnaire survey was made up of construction specialists who work in the field of public building construction. As a consequence, 50 questionnaire questionnaires were issued to professionals with minimum 5 years of experience in public building projects, and 27 responses were obtained. Engineers, quantity surveyors, architects, and town planners were among the professions. The details of the respondents are as given in Table 4.5.

Table 4.5: Respondents of Questionnaire Round

No	Professional	Experience In Construction Industry	No	Experience in Public Building Projects	No
1	Engineers	1 - 5 Years	-	1 - 5 Years	-
		6-10 Years	3	6-10 Years	4
		11-15 Years	5	11-15 Years	4
		16-20 Years	2	16-20 Years	2
2	Quantity Surveyors	1 - 5 Years	-	1 - 5 Years	-
		6-10 Years	2	6-10 Years	3
		11-15 Years	2	11-15 Years	1
		16-20 Years	2	16-20 Years	2

No	Professional	Experience In Construction Industry	No	Experience in Public Building Projects	No
3	Architects	1 - 5 Years	-	1 - 5 Years	-
		6-10 Years	4	6-10 Years	5
		11-15 Years	3	11-15 Years	2
		16-20 Years	-	16-20 Years	-
4	Town Planners	1 - 5 Years	2	1 - 5 Years	2
		6-10 Years	2	6-10 Years	2
		11-15 Years	-	11-15 Years	-
		16-20 Years	-	16-20 Years	-
Total			27		27

4.3.3 Findings of Questionnaire Survey

The Iron Triangle's components were to be ranked independently by respondents to a questionnaire survey. Each component, however, was examined separately using the data analysis technique RII, and the ultimate influence on the Iron Triangle was determined using the RII values obtained from each component. Further, studies of Peter et al., (2004) and Ameh (2010) have considered 0.7 as the cut-off value in their studies. However, the ranking of above studies was based on single scale. Even though, in this study, considering three scales, the cut-off RII value per component was considered as 0.8 and **Total values of more than 2.4 were selected as the causes which have a high impact on the Iron Triangle in Public Building Projects.** The influence on the Iron Triangle as a result of scope changes in public building projects is depicted in Table 4.6 below.

Table 4.6: Most Impacted Causes for Iron Triangle

No	Causes for Scope indeterminacy	Time	Cost	Quality	Total
		RII	RII	RII	
1	Lack of Planning	0.914	0.857	0.800	2.571
2	Lack of Concentrate on defining scope	0.886	0.914	0.771	2.571
3	Unclear scope	0.886	0.886	0.714	2.486
4	Lack of end-user inputs during the design stage	0.829	0.886	0.771	2.486
5	Poor Decision Making	0.857	0.829	0.800	2.486
6	impractical design	0.857	0.886	0.714	2.457
7	Failure to reach customer expectations	0.743	0.943	0.771	2.457
8	Unforeseen conditions	0.800	0.886	0.771	2.457
9	Design deficiencies	0.743	0.800	0.886	2.429
10	Project Priority	0.829	0.771	0.800	2.400
11	Political Influences	0.857	0.857	0.686	2.400
12	Poorly written scope	0.800	0.771	0.800	2.371

No	Causes for Scope indeterminacy	Time	Cost	Quality	Total
		RII	RII	RII	
13	Client Change	0.800	0.829	0.743	2.371
14	Poor effort estimation	0.800	0.829	0.743	2.371
15	Technological uncertainty	0.743	0.800	0.800	2.343
16	Scopes may be ambiguous	0.771	0.829	0.743	2.343
17	Change Cost	0.686	0.800	0.829	2.314
18	Lack of Clarity	0.743	0.800	0.771	2.314
19	Communication and Coordination Gaps	0.771	0.771	0.743	2.286
20	Quality Issue	0.686	0.771	0.800	2.257
21	poor coordination between the other relevant authorities	0.857	0.714	0.686	2.257
22	Lack of Motivation and Decision	0.743	0.743	0.743	2.229
23	Changes in Legislations	0.714	0.743	0.714	2.171
24	Project Risk	0.714	0.714	0.714	2.143
25	Changes in regulation	0.771	0.657	0.686	2.114
26	Poor Performance	0.686	0.686	0.686	2.057
27	Less effort on defining scope	0.629	0.657	0.657	1.943

According to the findings, the first key cause that has a substantial impact on the project Iron Triangle in scope indeterminacy is a *lack of planning*. In public building projects, time is the most impacted component due to a lack of preparation, and the other two components have a similar significant impact on the project due to the cause of scope changes.

The Iron Triangle suffers from a *lack of coordination when it comes to determining scope*. Due to difficulties in defining scope, a variety of scope changes may occur, with the cost having the most important impact. Furthermore, the project Iron Triangle has a similar affinity for *unclear scope*, as seen by the findings of the questionnaire survey.

Lack of end-user inputs during the design stage was derived as a new cause from the case study analysis and it has severe impact on the project Iron Triangle towards the scope indeterminacy. Time and cost are the most impacted components in this case compared to the quality.

According to the results of the questionnaire survey, *poor decision-making* has a major impact on the project Iron Triangle. Furthermore, *impractical designs* are another major factor that has a substantial impact on the project Iron Triangle. In this case, when compared to the quality of public building projects, time and cost are the most influenced causes.

As previously said, end user expectations are an important factor to consider in public building projects as the authority has a substantial impact on the project scope. *Failure to reach client expectations*, on the other hand, will inevitably lead to scope changes in these types of projects. Not only that, this cause has a significant impact on the project Iron Triangle in terms of cost more than time and quality.

Furthermore, *an unforeseen condition* has a significant impact on the Iron Triangle, as revealed by the results of the questionnaire survey. In comparison to the quality, time and cost are the most impacting factors. For example, the COVID 19 pandemic is one of the most prominent examples of an unforeseen event that had a variety of severe effects on project Iron Triangles in public building projects in last few years. In this scenario, the pandemic conditions had no severe impact on the quality of the productions. However, due to the pandemic conditions in the public building project, price escalation and duration increases were significant, as evidenced by the findings of the questionnaire survey.

Design deficiencies and a lack of project priorities are two factors to consider at the design stage, both of which have damaged the Iron Triangle. This study's cause has an essentially similar impact on all of the components.

Finally, political influence must be considered when evaluating the Iron Triangle's impact on Public Building Construction projects. In most situations, political difficulties had a major impact on time and expense when compared to the quality, as evidenced by the study's findings.

In addition to that, causes; *Poorly written scope, Client Change, Poor effort estimation* have significant impact on project time. However, due to the impact is minor in terms of cost and quality, these causes have been removed from the list of the most impacted causes.

Moreover, the causes; *Client Change, Poor effort estimation, Technological uncertainty, Scopes may be ambiguous, Change Cost and Lack of Clarity* have a significant impact on cost. However, due to the impact is minor in terms of time and quality, these causes have been removed from the list of the most impacted causes.

Furthermore, the causes; *Poorly written scope*, *Technological uncertainty*, *Change Cost and Quality Issue* have a significant impact on quality. However, due to the impact is minor in terms of time and cost, these causes have been removed from the list of the most impacted

Based on the finding of the questionnaire survey, eleven number causes were identified as the most impacted causes for the Iron Triangle in Public Building Projects and can be illustrate as follows in Figure 4.3,

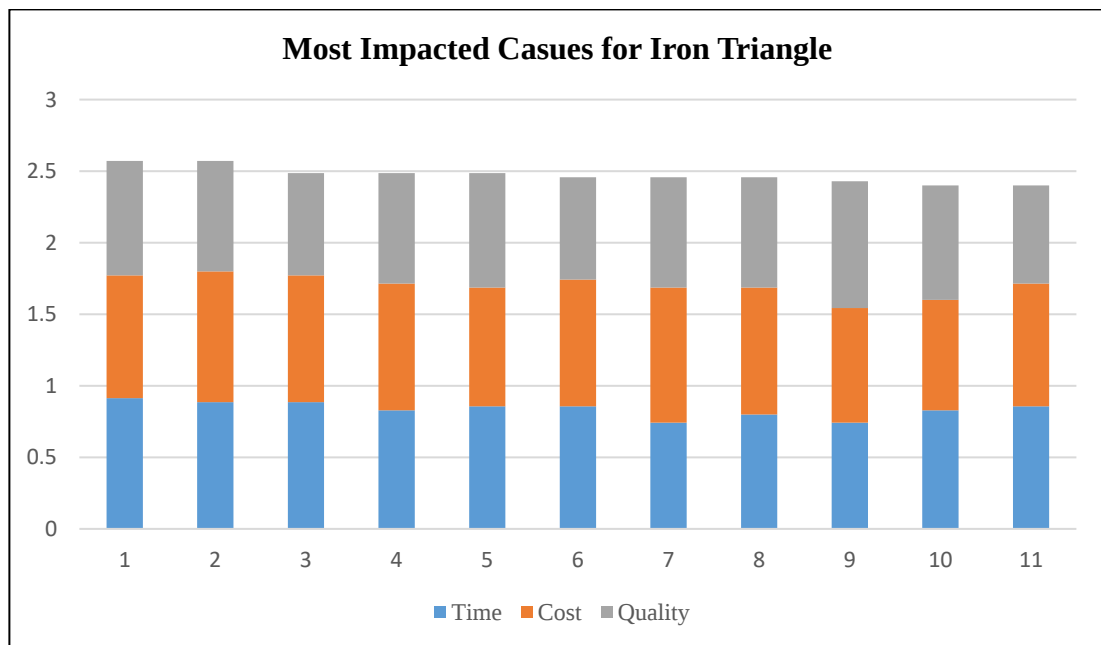


Figure 4.3: Most Impacted Causes for Iron Triangle

4.4 Additional Findings of the Research

When it comes to minimise these effects of scope indeterminacy, correct scope implementation in public building projects can be found to be the root cause of projects of this nature. Therefore, based on the literature (guidelines & standard documents) and expert opinions that the study had as support, this research also has elaborated on how to accurately implement scope in public building projects.

4.4.1 Process of Project Scope implementation in Government Projects

Public projects in Sri Lanka have been implemented by public institutions. To implement the public projects, there are certain process need to be followed. The National Planning Department of Ministry of Finance allocate the funds from the

Government Treasury. To approval of the project, Initially the National Planning Department shall approve the Project Concept and the project scope. When approval of the project scope with concept the project cost shall be allocated by the Ministry of Finance. Budgetary allocation in Quarterly basis provides for the implemented Agency according to the financial requirement and cash flow. Following figure 4.4 explains correct the procedure through a detailed diagram.

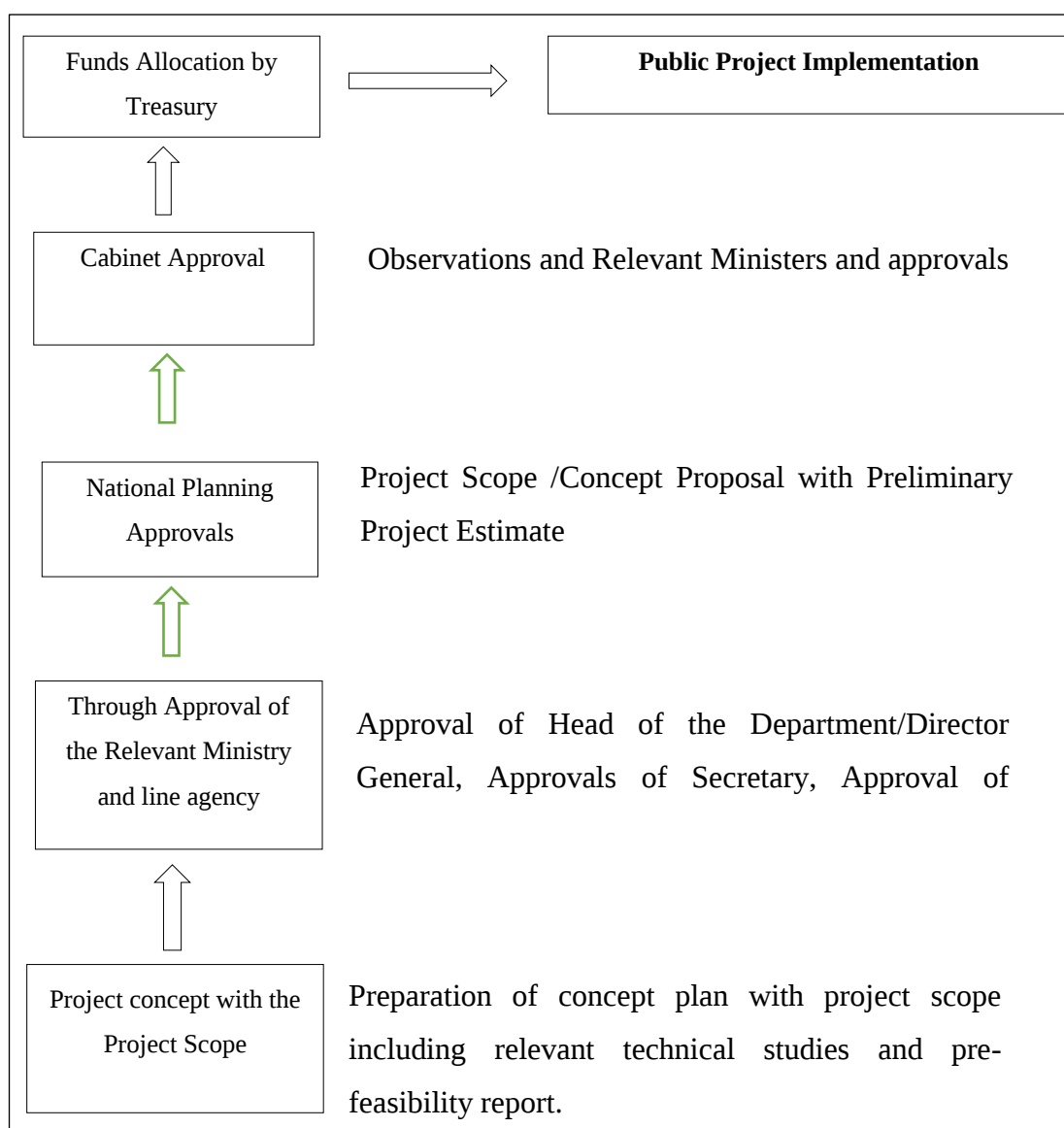


Figure 4.4: Government project Implementation Process

Budget allocation will be done by the ministry of finance for relevant ministries after approvals of certain procurement process and approvals as per the figure 4.4. For procurement process, apply Government Procurement Guidelines (NPD) and Manual

for work and services public project implementation. There are certain financial limits and authorities for project implementations.

According to the Procurement Guideline Reference 8.13.4 project scope changes /Variation to the public project very high burden to the government. Therefore, Procuring Entity must ensure that to minimise the scope changes. According to that all professionals involved in the project team shall responsible to effort minimise the government project scope changes.

4.5 Discussion

To fulfil the first objective of the study, a comprehensive literature review was conducted, which critically examined the phenomenon of indeterminacy in scope definition in the context of building projects. Furthermore, objectives 2 and 3 were partially fulfilled as a result of the literature review, which was based on previous research on scope indeterminacy.

4.5.1 Causes of Scope Indeterminacy

A thorough literature review was conducted to identify the main causes of scope indeterminacy in all types of building projects. However, the fundamental objective 2 is to identify the reasons for scope indeterminacy for the Public Building Projects. The data analysis was carried out along with case study reviews by experts in the Public Building Sector to achieve the stated aim of the objective.

Before the data analysis, the literature review identified 30 causes related to the general construction. The 30 causes of scope changes were determined utilising 45 references, and they applied to many types of building projects.

According to the Public Building Projects, 27 causes for scope indeterminacy were discovered as a result of the data analysis. As a consequence of the case study analysis, 6 additional causes were discovered among the 27. The remaining 23 causes were discovered through a literature review of construction projects in general. As a result, objective 2 was achieved, with 23 causes derived from the literature study and six additional causes derived from the data analysis findings.

4.5.2 Strategies to Minimise Causes of Scope Indeterminacy

Prior to the data analysis, literature review discovered 41 strategies to minimise or handle scope indeterminacy of public building projects. The strategies were identified utilising 14 references which are applicable to different types of building projects.

Based on the findings of the investigation, 34 strategies for dealing with scope indeterminacy in public building projects were discovered. As a result of the data analysis, 12 novel strategies were discovered. The remaining 22 strategies were identified in the literature review relating to general construction projects, and they can be used to public budding projects as well, according on the data analysis results.

4.5.3 Impact on Iron Triangle

Accordingly, 11 causes were found as having a significant impact on the study's Iron Triangle Performance. Comparing the final outcomes of the study with the literature finding, the following table elaborates the compare and contrast of most severe causes of the study with the literature findings.

Table 4.7: Compare and Contrast Literature Findings and Study Findings

#	Causes for Scope indeterminacy	Study Findings	Literature Findings													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Lack of Planning	√														
2	Lack of Concentrate on defining scope		√			√				√			√			
3	Unclear scope			√		√	√							√		
4	Lack of end-user inputs during the design stage	√														
5	Poor Decision Making	√														
6	impractical design				√					√						
7	Failure to reach customer expectations							√	√		√				√	
8	Unforeseen conditions				√						√					
9	Design deficiencies	√														
10	Project Priority						√					√				√
11	Political Influences	√														

1 - Zowghi&Nurmullani (2002); 2 - Gurlen (2003); 3 - Chan and Kumaraswamy (2002); 4 - Amoatey& Anson, (2017); 5 – Turk (2010); 6 - Bhise, (2013); 7 - Winuk, Gorschek, &Callele, (2016); 8 -Williams S., (2006); 9 - Bjarnason, Winuk, &Regnell, (2010); 10 - Wohlin& Andrews, (2001); 11 - Sauer, (2009); 12 - Muhammad Nabeel Mirza et al (2013); 13 - Berry, Czarnecki, Antkiewicz, & Abd-El-Razik, (2010); 14 -Williams, Vaughn, & Williams, (2006)

Based on the table, Lack of end-user inputs during the design stage, Design deficiencies, Poor Decision Making, Lack of Planning and Political Influences are 5 of the 11 causes that have a high Iron Triangle impact and were discovered as novel causes for the study through data analysis.

The remaining 6 causes with a high impact on the performance of the Iron Triangle were determined through a literature analysis based on prior studies on scope indeterminacy for various types of construction projects.

5. CONCLUSIONS AND RECOMMENDATIONS CHAPTER 05

5.1 Introduction

Public building projects are one of the most important types of construction projects in Sri Lanka, contributing a significant impact to the annual GDP of the country. Due to the importance of Public Building projects, it is a top priority to manage them according to effective Iron Triangle performance. Therefore, this chapter discussed the ultimate aim of the study; impact of scope definition indeterminacy on Iron Triangle performances in public building construction projects and objectives which have achieved through the data analysis. Further, to enhance the effectiveness of public building projects, this chapter has provided appropriate recommendations with further study options.

5.2 Conclusion

The study aimed to investigate the impact of indeterminacy of scope definition on Iron Triangle performances in Public Building Projects. However, the aim was achieved through four number objectives which can be explained as follows;

5.2.1 Objective 1: Critically review the phenomena of indeterminacy of scope definition in the context of construction projects

The literature review was carried out to conduct a critical review of the scope indeterminacy. The importance of specifying the scope and the indeterminacy of scope impact on the project Iron Triangle were explored in the overall literature review. In addition, management solutions for reducing scope changes in general construction projects were discovered. Furthermore, using the literature evaluation, critically examined the effects of scope indeterminacy by measuring the impact of scope.

5.2.2 Objective 2: Identify the causes behind the indeterminacy of project scope definition in Public Building Projects

During the literature review, the main causes of scope indeterminacy were determined. The causes that were uncovered through the literature review, on the other hand, applied to all construction projects. As a result, a case study analysis was conducted to determine the causes of scope indeterminacy in Public Building Construction projects. There were 27 number causes found as a result of the findings. Ten number causes

were recognised as the most prevalent causes of scope indeterminacy, five number causes were classified as common causes, and the other twelve causes were classified as unique causes of scope indeterminacy.

5.2.3 Objective 3: Develop strategies to minimise the impact of indeterminacy of project scope definition on Iron Triangle Performance in public sector projects.

Objective 3, management strategies for scope indeterminacy in general construction projects was established through a literature review at the initial stage of the study. The number of strategies was raised to fifty-three after the case study examination. Finally, based on the findings, thirty-four management strategies for reducing scope indeterminacy in public building projects were chosen. Thirteen of the thirty-four tactics were labelled as Very Common Strategies for Public Building Projects, while the remaining twenty-one were labelled as Unique Strategies for Public Building Projects.

5.2.4 Objective 4: Appraise the impact of indeterminacy of project scope definition on Iron Triangle Performance in public sector projects

The cause of scope indeterminacy in public building projects was chosen as the primary driver in order to determine the Iron Triangle impact while assessing the influence of scope indeterminacy on the Iron Triangle. Based on the findings of the survey, eleven causes with a high Iron Triangle impact were chosen as the most severed causes of Iron Triangle in public building projects. The causes are as follows: *Lack of Planning, Lack of Concentrate on defining scope, Unclear scope, Lack of end-user inputs during the design stage, Poor Decision Making, impractical design, Failure to reach customer expectations, Unforeseen conditions, Design deficiencies, Less Project Priority and Political Influences.*

5.3 Recommendations

The final conclusions can be utilised to guide Public Building projects in managing or reducing the impact of scope indeterminacy. Furthermore, understanding the causes of scope indeterminacy allows for a better understanding of the effects that can occur on the Iron Triangle in Public Building Construction projects.

When analysing the sources of scope impertinency, it is recommended that the influence of these factors be reduced and that suitable standards for properly defining scope be followed. Furthermore, the causes that have a significant impact on the project Iron Triangle can be minimised using the strategies discovered during the investigation.

Furthermore, it is the primary responsibility of the defining scope to give proper priority to minimising errors and adhering to specifications. And since public building projects are strongly linked with the government, which need follow a strict code of ethics to ensure that the project runs well. In order to retain the good being in the Public Building Projects, political influences should be greatly reduced.

Further, the following recommendations can also be suggested as a result of this research.

- Project scope must be finalised by the relevant professionals at the right time with accurate budget.
- Before finalise the Project scope the project team must gather the relevant information such as priority of the project, urgency, national requirement. otherwise, public money can be wasted for unnecessary
- Before finalise the project scope, stakeholder's analysis must be complete. All stakeholders must aware of the project scope before start of the project
- An effective project management and control system must be use for all types of projects.
- Planning and Building Regulation shall be updated within reasonable period
- Proper Project planning can reduce the Scope changes during the implementation stage.
- Proper project management tools need to be introduced to manage the public projects.
- Proper attention to force majeure situation needs to be provide when doing the feasibility study,

- Political influences can be greatly reduced when apply the good Governance in the procurement Process

5.4 Limitations of the Study

The research was conducted in relation to public building projects. As a result, the goals may be limited to public building projects as compared to other construction projects. However, in some cases, the findings can be applied to other construction projects as well. Furthermore, cases were chosen in conformity with the Sri Lankan environment. As a result, the analysis was limited to the Sri Lankan context.

5.5 Further Researches

Some more research areas can be highlighted as a guide for researchers in this field in order to improve the effectiveness of the Public Building projects

- Improve Iron Triangle Performance from Early-Stage Precautions in Public Building Projects
- Influence of Extension of time claims due to scope indeterminacy of Public Building Projects

REFERENCES

- Aaker, A., Kumar, V., & George, S. (2000). *Marketing Research*. . New York: John Wiley & Sons Inc.
- Akhtar, I. (2016). Research Design. Research in Social Science. *Interdisciplinary Perspectives*.
- Alexandra, I., & Beus-Dukic, L. (2009). *Discovering requirements: how to specify products and services* (1st ed.). West Sussex: John Wiley & Sons.
- Ali Delay Causes of Road Construction Project in Egypt, Master thesis, Faculty of Engineering Alexandria University, Egypt (2013)
- Alinaitwe, R., Apolot, R., & Tindiwensi, D. (2013). Investigation into the causes of delays and cost overruns in Uganda's public sector construction projects. *Journal of Construction in Development Countries*, 33-47.
- Al-Momani, A. (2000). Construction delay: a quantitative analysis. *International Journal of Project Management*, 18(1), 51-59.

Al-Nuiami, A., Taha, R., Al-Mohsin, M., & Al-Harthi, A. (2010). Causes, Effects, Benefits, and Remedies of Change Orders on Public Building Construction Projects in Oman. *Journal of Construction Engineering and Management*.

Alsuliman, J. (2019). Causes of delay in Saudi Public Building Construction projects. *Alexandria Engineering Journal*.

Ameh, O., Aliu, S., & Odusami, K. (2010). Significant factors causing cost overruns in telecommunication projects in Nigeria. *Journal of Construction in Developing Countries*, 15.

Amoatey, C., & Anson, B. (2017). Investigating the major causes of scope creep in real estate construction projects in Ghana. *Journal of Facilities Management*, 15.

Apuke, O. (2017). Quantitative Research Methods : A Synopsis Approach. *Arabian Journal of Business and Management Review*, 40-47.

Article, R. (2013). critical failure factors in information system. *Journal of Global Researchers in Computer Science*, 4(1), 76-82.

Assbeihat,& Sweis, (2015). Factors affecting change orders in Public Building Construction projects. *International Journal of Applied*, 5(6).

Assaf, S., & Al-Hejji, S. (2006). Causes of delay in large construction projects. *International journal of project management*, 24(4), 349-357.

Association, I. P. (2015). *Individual Competence Baseline for Project, Programme & Portfolio Management* (4th ed.). Zurich: IPMA.

Aziz, R., & Abdel-Elkhalek, S. (2016). Expected Time Delays Prediction for Egyptian Construction Projects. *Ninth Alexandria international conference on Structural and Geotechnical Engineering, "AICSGE9"* (pp. 11-22). Alexandria: Faculty of Engineering, Alexandria University.

Ayal, (2005). Effect of Scope Changes on Project Duration Extensions. Tel Aviv University.

Badariah, S., Sahibuddin, S., & Ghani, A. A. (2009). Re-defining requirements engineering process improvement model. *16th Asia-Pacific Software Engineering Conference*, 16, pp. 87-92. Penang.

- Badewi, A. (2016). The impact of project management (PM) and benefits management (BM) practices on project success: Towards developing a project benefits governance framework. *International Journal of Project Management*, 34, 761-778.
- Bano, M., Imtiaz, S., Ikram, N., Niazi, M., & Usmani, M. (2012). Causes of requirement change a systematic literature review. *Evaluation & Assessment in Software Engineering (EASE)* (pp. 22-31). IET.
- Barry, E.J., Mukhopadhyay, T., & Slaughter. S.A. 2002. Software Project Duration and Effort: An Empirical Study. *Information Technology and Management*, 3(1-2): 113-136.
- Bassa, M., Ashenafi, R., Ashebir, A., & Mamo, T. (2019). Causes and Effects of Design Change in Building Construction Projects in Three Selected Southern Ethiopia Zones. *International Journal Of Engineering Research & Technology*, 8(12).
- Berry, D., Czarnecki, K., Antkiewicz, M., & Abd-El-Razik, M. (2010). Requirements Determination is Unstoppable: An Experience Report. *18th IEEE International Requirements Engineering Conference* (pp. 311-316). IEEE.

- Berssaneti, F., & Carvalho, M. (2015). Identification of variables that impact project success in Brazilian companies. *International Journal of Project Management*, 33, 638-649.
- Bhise, V. (2013). Product Attributes, Requirements, and Allocation of Functions. *System Engineering Proceedss Technology*, 1, 73-96.
- Bingham, E., Gibson, J., & Cho, J. (2011). *Effective early planning for pipeline projects.*” *Pipelines 2011: A sound conduit for sharing solutions*. Seattle: ASCE, Pipelines Division.
- Bjarnason, E., Winuk, K., & Regnell, B. (2010). Over scoping: Reasons and Consequences: A case study on decision making in software product management. *Software Product. Management.* , 30-39.
- Bjarnason, E., Winuk, K., & Regnell, B. (2011). Requirements are slipping through the gaps — A case study on causes & effects of communication gaps in large-scale software development. *2011 IEEE 19th International Requirements Engineering Conference* (pp. 37-46). IEEE.

Bjarnson, E., Winuk, K., & Regnell, B. (2012). Are you biting off more than you can crew? A case study on causes and effects of over scoping in large-scale software engineering. *Information and Software Technology*, 37-46.

Blumberg, B., Cooper, D., & Schindler, P. (2005). *Business Research Methods*. . McGraw-Hill: Maidenhead.

Boru, T. (2018). Research Methodology. *University of South Africa, PHD Thesis*.

Bourne, L., & Walker, D. T. (2004). Advancing project management in learning organizations. *Learning Organization*, 226-243.

Brown, T. (2006). *Confirmatory factor analysis for applied research*. . New York: Guilford.

Bryde, D. (2008). Perceptions of the impact of project sponsorship practices on project success. *International Journal of Project Management*, 26, 800-809.

Camilleri, E. (2011). *Project Success: Critical Factors and Behaviors*. Burlington: Gower Publishing Company.

- Carter, R., Anton, A., Dagnino, A., & Williams, L. (2001). Evolving beyond requirements creep: a risk-based evolutionary prototyping model. *Fifth IEEE International Symposium on Requirements Engineering* (pp. 94-101). IEEE.
- Cerezo-Narvaez, A., Otero-Mateo, M., & Pastor, A. (2016). Influence of scope management in construction industry projects. *Dyna Management*, 4(1).
- Chan, D., & Kumaraswamy, M. (2002). Compressing construction durations: lessons learned from Hong Kong building projects. *International Journal of Project Management*.
- Chen, C., Law, C. H., & Yang, S. (2009). Managing ERP Implementation Failure: A Project Management Perspective. *IEEE Transactions on Engineering Management*, 56(1).
- Chick, D. 1999. The time value of project change. *Cost Engineering*, 41(6): 27-31.
- Cho, C., & Gibson, E. (2001). Building project scope definition using project definition rating index. *Journal of architectural engineering*, 7(4), 115-125.

Cho, C., & Gibson, G. (2001). Building project scope definition using project definition rating index',. *Journal of Architecture Engineering*, 7(4), 115-125.

Cho, C., Furman, J., & Gibson, G. (1999). *Development of the project definition rating index (PDRI) for building projects*. . Austin, TX.: Construction Industry Institute.

Chol, C.-S., & Gibson, G. (2001). Building Project Scope Definition Using Project Definition Rating Index Members. *Journal of Architecture Engineering* , 102-125.

Ciccareli, J. (2012). Avoiding the pitfalls of scope creep on construction projects. *Live Audio Conference*. Lorman Education Services . Retrieved from Live Audio Conference : <http://les.brochure.s3.amazonaws.com/388555.pdf>

CII (1990), The Impact of Changes on Construction Cost and Schedule, Construction Industry Institute, University of Texas at Austin, Austin, Texas

Clancy, T. (1995). *Chaos, The Standish Group Report*. The Standish Group.

Clark, T. (2014). *How to manage scope creep and even prevent it from happening*. Retrieved from Liquid Planner: www.liquidplanner.com/blog/manage-scope-creep-even-prevent-happening/

Cox, R., K. (1997), Managing Change Orders and Claims, *Journal of Management in Engineering*, 13(1), pp: 24-29

Creedy, G. (2005). Risk factors leading to cost overrun in highway projects. Sidwell, A.C. (Ed.). *Proceeding of. Queensland University of Technology Research Week International Conference*, (pp. 4-8). Brisbane, Australia.

Cropley, A. (2021). *Introduction to Qualitative Research Methods*.

Denny, L. (2018, February 14). *Project Scope and Product Scope in Project Management*. Retrieved from Project Cubicle: <https://www.projectcubicle.com/project-scope-and-product-scope/>

Derenskaya, Y. (2018). Project Scope Management Process. *Baltic Journal of Economic Studies*, 118-125.

Dinku, A., & Kahssay, G. (2003). Claims In International Construction Projects In Ethiopia And Case Studies On Selected Projects. *Journal of EEA*, 20.

Di-Thommazo, A., Camargo, K., Hernandes, E., Goncalves, G., Pedro, J., Belgamo, A., & Fabbri, A. (2015). Using the dependence level among requirements to prioritize the regression testing set and characterize the complexity of requirements change. *17th International Conference on Enterprise Information Systems* (pp. 231-241). ICEIS.

Dixon, M. (2006). Identity risks-scope creep. *Blogs Oracle*, 1-20.

Doll, S. (2001). *Seven steps for avoiding scope creep*. Retrieved from TechRepublic: www.techrepublic.com/article/seven-steps-for-avoiding-scope-creep/

Dumont, P., Gibson, J., & Fish, J. (1997). Scope management using project definition rating index. ”. *Journal of Management Engineering*, 54-60.

Dvir, D., & Letcher, T. (2004). Plans are nothing, changing plans is everything: The impact of changes on project success. *33*(1), 1-15.

Dvir, D., Lipovetsky, S., Shenhar, A., & Tishler, A. (1998). In search of project classification: a non-universal approach to project success factors. *Research Policy*, 27(9), 915-935.

Ebbesen, J., & Hope, A. (2013). Re-imagining the Iron Triangle: Embedding Sustainability into Project Constraints. *PM World Journal*.

Ebert, C., & De-Man, J. (2005). Requirements uncertainty: influencing factors and concrete improvements. *27th International Conference of Software Engineering* (pp. 553-560). ICSE.

Ehsan, N., Waheed, K., Asgher, U., Nawaz, M., Mirza, E., & Sheikh, Z. (2010). Effects of project manager's competency on project success. 107-112.

Ertel, D., & Rudner, S. 2000. Scope change negotiations: Are write-off inevitable? *Consulting to Management*, 11 (2): 3-8.

Fageha, M., & Aibinu, A. (2013). Managing Project Scope Definition to Improve Stakeholders, Participation and Enhance Project Outcome. *Procedia - Social and Behavioral Sciences*, 74(29), 154-164.

Fageha, M., & Aibinu, A. (2013). Managing Project Scope Definition to Improve Stakeholders' Participation and Enhance Project Outcome. *Procedia-Social and Behavioral Sciences*, 74, 154-164.

Fageha, M., & Aibinu, A. (2013). Managing Project Scope Definition to Improve Stakeholders' Participation and Enhance Project Outcome". *Procedia-Social and Behavioral Sciences*, 74, 154-164.

Figgou, L., & Pavlopoulos, V. (2015). *Social Psychology: Research Methods*. Retrieved from Science Direct: <https://www.sciencedirect.com/topics/social-sciences/narrative-analysis>

Fitsilis, P., Damasiotis, V., & O'Kane, J. (2015). Scope management complexity in software projects.

Flyvbjerg, B., Holm, M., & Buhl, S. (2003). How common and how large are cost overruns in transport infrastructure projects. *Journal of American Planning Association*, 23(1), 71-88.

Flyvbjerg, B., Holm, M., & Buhl, S. (2002). Underestimating costs in public works projects: Error or lie? *Journal of the American Planning Association*, 68(3), 279-295.

Freshman-Caffrey, K. (2014). *Foreseeing Sees: reducing the hidden cost of professional services*. Retrieved from IBIS World: <http://media.ibisworld.com/wp-content/uploads/2014/11/Hidden-Costs-Professional-Services1.pdf>

Gharaee, M. (2012). Change Management and Change Process Model for the Iranian Construction Industry. *A Journal of Management*, 2(2), 85-89.

Gibson, J. E., Wang, Y., Cho, C., & Pappas, M. (2006). What Is Pre project Planning. *Journal of management in engineering*, 24(4), 35-42.

Gosh, S. (2015). Systemic Comparison of the Application of EVM in Traditional and Agile Software Project. *Journal of Project Management*, 1-14.

Goundar, S. (2012). Chapter 3 - Research Methodology and Research Method. Retrieved from https://www.researchgate.net/publication/333015026_Chapter_3__Research_Methodology_and_Research_Method

Grossoehme, D. (2014). Overview of Qualitative Research. *Journal of health care chaplaincy*.

GurlenS. (2003). *Scope Creep*. Retrieved from UMSL: www.umsl.edu/sauterv/analysis/6840_f03_papers/gurlen/

Halloum, M., & Bajracharya, A. (2012). Cost and time overrun revisited: A study on the infrastructure construction projects in Abu Dhabi, UAE. *The Third Conference on Construction in Developing Countries*. Bangkok, Thailand.

Hanna, A., & Gunduz, M. (2004). Impact of change orders on small labor-intensive projects. *Journal of Construction Engineering and Management*, 130(5), 726-733.

Hanna, A. S., Camlic, R., Peterson, P. A., Nordheim, E. V. (2002), Quantitative Definition of projects Impacted by Change Orders, *Journal of Construction Engineering and Management*. 128(1).

Hans, R. (2013). Hans, Robert. (2013). Work Breakdown Structure: A Tool for Software Project Scope Verification. *International Journal of Software Engineering & Applications*, 4.

Hussain, E., Farooqui, R., Umer, M., & Lodi, S. (2012). Factors affecting construction cost in the Pakistani construction industry.

Hussain, O. (2012). Direct cost of scope creep in governmental construction projects in qatar. *Global Journal of Management and Business Research*, 2-25.

Hussain, O. (2012). Direct Cost Of Scope Creep In Governmental Construction Projects In Qatar. *Global Journal of Management and Business Research*, 12.

Hussain, S., Ehsan, N., & Nauman, S. (2010). Hussain, Sabeen & Ehsan, N. & Nauman, Shazia. (2010). A strategic framework for requirements change in technical projects. *Case study of a R&D project*.

Ijaola, I. A. & Iyagba, R. O., (2012). A Comparative Study of Causes of Change Orders in Public Building Construction Project in Nigeria and Oman. *Journal of Emerging Trends in Economics and Management Siences*, pp. 95-501

Institute for Construction Training and Development. (2007). *Standard Bidding Document Procurement of Works Major Contracts* (2nd ed.). Ministry of Housing and Construction.

Institute for Construction Training and Development. (2003). *Standard Bidding Document Procurement of Works Design and Build Contracts* (1st ed.). Ministry of Housing and Construction.

Institute, P. M. (2008). *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*. Newtown Square, Pennsylvania, USA: Project Management Institute.

Institute, P. M. (2013). *A Guide to the Project Management Body of Knowledge: (5th ed.)*. Newtown Square: PMI.

Jackson, R., Drummond, D., & Camara, S. (2007). What Is Qualitative Research. *Qualitative Research Reports in Communication*, 21-28.

Jilcha, K. (2019). Research Design and Methodology. *intechopen*.

Jones, T., Baxter, M., & Khanduja, V. (2013). A quick guide to survey research. *Annals of the Royal College of Surgeons of England*, 5-7.

Josephson, P., & Hammarlund, Y. (1999). The causes and costs of defects in construction. *A study of seven building projects*, " *Automat. Construction*, 642-681.

Kagioglou, M., Cooper, R., Aouad, G., & Sexton, M. (2000). Rethinking construction: the generic design and construction process protocol. *Journal of Engineering Construction and Architectural Management*, 7(2), 141-153.

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2007). The worldwide governance indicators project: answering the critics. *Policy Research Working Paper Series*.

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2007). *The worldwide governance indicators project: answering the critics*, Policy Research Working Paper Series. The World Bank.

Kaur, R., & Sengupta, J. (2011). Software Process Models and Analysis on Failure of Software Development Projects. *International Journal of Science and Engineering Researches*, 2(2), 1-4.

Kerzner, H. (2006). *Project Management Best Practises*. New York : Achieving Global Excellence.

Kerzner, H. (2007). Project management-best practices: achieving global excellence. *IEEE Transformation Engineering Management*, 54(2).

Khan, A. (2006). Project Scope Management. *48*(6), 12-17.

Khan, H., & Abdul-Qadir-Khan, T. (2015). Effects of Lowest Bidding Bid Awarding System in Public Sector Construction Projects in Pakistan. *Global Journal of Management And Business*, *15*(1).

Koskela, L. (2002). The underlying theory of project management is obsolete. Paper presented at PMI® Research Conference 2002. *Frontiers of Project Management Research and Application*. Seattle, Washington: Project Management Institute.

Kumaraswamy, M., & Chan, W. (1998). Contributors to construction delays. *Construction Management and Economics*, *16*(1), 17-29.

Kumari, N., & Pillai, A. (2014). A study on project scope as a requirements elicitation issue. Computing for Sustainable Global Development (INDIACom). *International Conference on IEEE* (pp. 510-514). IEEE.

Lampa, I., Contessoto, A., Amorim, A., Zafalon, G., Valencio, C., & Souza, R. (2017). Project Scope Management: A Strategy Oriented to the Requirements Engineering. *ICEIS*.

Larshen, J., Shen, G., Lindhard, S., & Brunoe, T. (2016). 'Factors Affecting Schedule Delay, Cost Overrun, and Quality Level in Public Building Construction Projects. *Journal of Management in Engineering*, 32.

Liberzon, V., & Shavyrina, V. (2013). Methods and Tools of Success Driven Project Management. *Project Perspectives*, 35, 32-37.

Liberzon, V., & Shavyrina, V. (2013). Methods and Tools of Success Driven Project Management. *Project Perspectives*, 35, 32-37.

Lieberman, B. (2001), Management: The Rational edge
[http://www.therationaledge.com/content/sep 26 m project scope management bl.html](http://www.therationaledge.com/content/sep%20m%20project%20scope%20management%20bl.html)

Lim, C. (2000). An exploratory study into recurring construction problems. *International Journal of Project Management*, 18(4), 267-273.

Lin, C., Tang, K., Chen, C., & Kapfhammer, G. (2012). Reducing the Cost of Regression Testing by Identifying Irreplaceable Test Cases. *2012 Sixth International Conference on Genetic and Evolutionary Computing* (pp. 257-260). ICGEC.

- Love, P. D., & Edwards, D. (2004). Forensic project management: the underlying causesn of rework in construction projects. *Civil Engineering and Environmental Systems*, 21(3), 207-228.
- Madhuri, K. (2014). Influence of Domain and Technology upon Scope Creep in Software Projects. 1-6.
- Madhuri, K., & Suma, J. (2014). Effect of Scope Creep in Software Projects – Its Bearing on Critical Success Factors. *International Journal of Computer and Applications*, 106(2), 9-13.
- Mahamid, I. (2013). Contributors to Schedule Delays In Public Building Construction Projects in Saudi Arabia: Owners' Perspective. *Journal of Construction Project Management and Innovation*, 3(2), 608-619.
- McQuighan, M., & Hammell, R. (2011). Scope as a Leading Indicator for Managing Software Development. *Software Engineering Research, Management and Applications* (pp. 235-241). IEEE.
- Menike, T. M. C. H. (2015). Evaluation of factors affecting project scope change in Sri Lankan building construction industry.

Mirza, M., Pourzolfaghar, Z., & Shahnazari, M. (2013). Significance of Scope in Project Success. *Procedia Technology*, 9.

Mirza, M., Pourzolfaghar, Z., & Shahnazari, M. (2013). Significance of Scope in Project Success. *Procedia Technology*, 9.

Mokoena, T., Pretoris, J., & van-Wyngaard, C. (2013). Triple Constraint Considerations in the Management of Construction Projects. *2013 IEEE International Conference on Industrial Engineering and Engineering Management* (pp. 813-817). IEEE Conference Publications.

Molokken-Ostfold, K., & Jorgensen, M. (2005). A comparison of software project overruns - flexible versus sequential development models. *IEEE Transactions on Software Engineering*, 31(9), 754-766.

Moore, F. (2016). Qualitative vs Quantitative Research. Retrieved from https://www.researchgate.net/publication/310101530_Qualitative_vs_Quantitative_Research

Morris, R., & Sember, B. (2008). Project Management That Works: Real-World Advice on Communicating, Problem-Solving, and Everything Else You Need to Know to Get the Job Done. *AMACO*.

Motele, L., Mbachu, J., & Nkado, R. (2003). An investigation into material wastages on building sites. *CIDB 1st Postgraduate Conference*, , (pp. 288-295). Port Elizabet.

Mulla, S., & Waghmare, A. (2015). A Study of Factors Caused for Time & Cost Overruns in Construction Project & their Remedial Measures.

Muller, R., & Turner, R. (2007). The influence of project managers on project success criteria and project success by type of project. *European Management Journal*, 25(4), 298-309.

Nabeel, M., Pourzolfaghar, Z., & Shahnazari, M. (2013). Significance of Scope in Project Success,” Int. Conf. Project Management. *Interantional Conference in Project Management*, 9, 722-729.

Nahod, M. (2012). Scope Control Through Managing Changes in Construction Projects. *Organization, Technology & Management in Construction: An International Journal*, 4.

Nahod, M.-M. (2012). Scope Control Through Managing Changes in Construction Projects. *Organization. Technology & Management in Construction: An International Journal*, 4.

Narvaez, A., Mateo, M., & Fernandez, A. (2016). Infulence of Scope Management in Construction Industry Projects . *Dyna Management*, 1-15.

National Procurement Agency. (2006). *Procurement Guidelines*. Department of Government Printing.

National Procurement Agency. (2006). *Procurement Manual*. Department of Government Printing.

Neetu-Kumari, S., & Pillai, A. (2014). A study on project scope as a requirements elicitation issue," . *2014 International Conference on Computing for Sustainable Global Development* (pp. 510-514). IEEE.

Neimat, A. (2005). Why IT Projects Fail. *Project Perfect*, 1-8.

Nicolini, D., Tomkins, C., Holti, R., & Oldman, A. (2000). Can Target Costing and Whole Life Costing be Applied in the Construction Industry? *Evidence from Two Case Studies*, 11(4), 303-324.

Noman, A., Bakhsh, A., Alnajjar, N., & Attar, A. (2018). Causes of delays in public and private construction projects in Saudi Arabia. *Journal of Construction Management*, 51(1), 71-78.

Odeh, A., & Battaineh, H. (2002). Causes of construction delay: traditional contracts. *International Journal of Project Management*, 20(1), 67-73.

Odeyinka, H., & Yusif, A. (1997). The causes and effects of construction delays on completion cost of housing projects in Nigeria. *Journal of Financial Management of Property and Construction*, 2(3), 31-44.

Oladapo, A. (2007). A quantitative assessment of the cost and time impact of variation orders on construction projects. *Journal of Engineering, Design and Technology*, 5(1), 35-48.

Olsson , N. (2015). Implementation of Pre-defined Potential Scope Reductions in Projects. *Procedia Computer Science*, 64.

Osman, Z.O. (2009), The Potential effect of Variation orders in construction projects *Journal of engineering Annals*,VII (Fascicule 2),141-152.

Peter, E., Love, D., Irani, Z., & David, J. (2004). A Rework Reduction Model for Construction Projects. *IEEE Engineering Management*, 51(4).

Pinto, J. (2010). Project Management: Achieving Competitive Advantage. *New Jersey: Pearson Education*.

Polee, R., & Samuel, P. (2011). Transportation Mega-Projects and Risk . *Reason Foundation Policy Brief*, 2-97.

Pollack, J., Helm, J., & Adler, D. (2018). What is the Iron Triangle, and how has it changed. *International Journal of Managing Projects in Business*, 11(2), 527-547.

Prieto, R. (2019). The Primacy of the Scope Baseline in Engineering & Construction Projects.

Puhl, S., & Fahney, R. (2011). How to assign cost to “avoidable requirements creep”: A step towards the waterfall's agilization. *2011 IEEE 19th International Requirements Engineering Conference* (pp. 307-312). IEEE.

Punch, K. (2005). *Introduction to Social Research—Quantitative & Qualitative Approaches*. . London: Sage.

Ram, A. (2010). *Research Methodology*. New Delhi: : Rawat Publication.

Rehman, I., Rauf, A., & Shahid, A. (2010). Scope management in agile versus traditional software development methods. *2010 National Software Engineering Conference* (p. 10). ACM.

Reteana, R. (2014). *BIM scope creep*. Retrieved from BIM Think Space: [www.bimthinkspace.com/2014/08/bim-scope creep.html](http://www.bimthinkspace.com/2014/08/bim-scope%20creep.html)

Sauer, C. (2009). Rethinking IT projects management: Evidence of a new mind set and its implications. *International Journal of Project Management*, 27, 182-193.

Saunders, M., Lewis, P., & Thornhill, A. (2007). *Research Methods for Business Students. 4th Edition*, . Harlow: Financial Times Prentice Hall, Edinburgh Gate

Senouci, A., Ismail, A., & Eldin, N. (2016). Time Delay and Cost Overrun in Qatari Public Building Construction Projects. *Procedia Engineering*, 368-375.

Shah, R. (2016). An exploration of causes for delay and cost overruns in construction projects: case study of Australia, Malaysia & Ghana. *Journal of Advanced College of Engineering and Management* , 41-55.

Shanmugapriya, S. (2013). Investigation of Significant Factors Influencing Time and Cost Overruns in Indian Construction Projects. *International Journal of emerging Technology & advanced engineering*, 3(10).

Shebob, A., Dawood, N., Shah, R., & Xu, Q. (2012). Comparative study of delay factors in Libyan and the UK construction industry. , 19(6), 688–712. *Engineering, Construction and Architectural Management*, 19(6), 688-712.

Shenhar, A. (1993). From Low to high-tech project management. *R&D Management*, 23(3), 199-214.

Shenhar, A., & Dvir, D. (2007). *Reinventing Project Management: The Diamond Approach To Successful Growth And Innovation*, 1st ed. Harvard Business School Press (1st ed.). Harvard Business School Press.

Shrestha, P., Burns, L., & Shields, D. (2013). Magnitude of construction cost and schedule Overruns in Public Work Projects. *Journal of Construction Engineering*, 1-9.

Stojcetovic, B. (2013). Project management: cost, time and quality. *8th International Quality Conference*, 345-350.

Suma, R., & Madhuri, K. (2013). Influence of Scope Creep on Project Success: A Comparative Study between Conventional Approach Verses Agile Approach. 851-855.

Symeou, L., & Lamprianou, I. (2008). Approaches of research and methodology.

Tesfaye, E., Lemma, T., Berhan, E., & Beshah, B. (2017). Key project planning processes affecting project success. *International Journal for Quality Research*, 1-10.

Thakurta, R., & Dasgupta, S. (2011). Impact of Software Requirement Volatility Pattern on Project Dynamics: Evidences from a Case Study. *International Journal of Software Engineering & Applications*, 2011-2302.

Thomas, H., & Napolitan, C. (1995). Quantitative effects of construction changes on labor productivity. *Journal of Construction Engineering and Management*, 121(3), 290-296.

Turk, W. (2010). *Scope Creep Horror*. Retrieved from dau.mil: [www.dau.mil/pubscats/atl%20docs/mar apr10/turk_mar-apr10.pdf](http://www.dau.mil/pubscats/atl%20docs/mar%20apr10/turk_mar-apr10.pdf)

Turner, J. (1999). Project management: A profession based on knowledge or faith? (Editorial). *International Journal of Project Management*, 329-330.

Turner, R., & Bredillet, C. (2009). *Perspectives on Projects*. Taylor & Francis. *WCED, 1987. Our Common Future*. Oxford: Oxford University Press.

Usmani, F. (2021, July 2). *Project Scope vs Product Scope*. Retrieved from PM Study Circle: <https://pmstudycircle.com/product-scope-vs-project-scope/>

Van-Nguyen, T. (2009). Claims in Building Project in Public Sector: Case Study in Mekong Area, Vietnam Building projects in Mekong Delta, Vietnam.

van-Wyngaard, C., Pretorius, J., & Pretorius, L. (2012). Deliberating Triple Constraint Trade-offs as Polarities to Manage – a Refreshed Perspective. *2013 IEEE International Conference on Industrial Engineering and Engineering Management* (pp. 1265-1272). IEEE Conference Publications.

van-Wyngaard, C., Pretorius, J., & Pretorius, L. (2012). Theory of the Triple Constraint – A Conceptual Review. *2012 IEEE International Conference on Industrial Engineering and Engineering Management* (pp. 1991-1997). IEEE Conference Publications.

Vargas-Hernandez, J., Arandia, O., & Cordova-Rangel, A. (2016). A Review of Research Methods in Strategic Management; What Have Been Done, and What is Still Missing.

Vaus, D. (2001). *Research Design in Social Research*. New Delhi: Sage Publication.

Venkatesh, V., Brown, S., & Bala, H. (2013). Bridging the qualitative-quantitative divide. *Guidelines for conducting mixed methods research in information systems. MIS Quarterly*, 37(1), 21-54.

Verner, J., & Sampson, J. (2008). "What factors lead to software project failure? *Second International Conference on Research Challenges in Information Science* (pp. 71-80). IEEE.

Verner, J., Cox, K., Bleistein, S., & Cerpa, N. (2005). Requirements Engineering and Software Project Success: an industrial survey in Australia and the US. *Australian Journal of Information Systems*, 13(1), 225-238.

Wang, Y., Gibson, G., & Al, U. A. (2006). Pre-Project Planning and Its Practice in Industry. *International Symposium on Automation and Robotics in Construction*, 878-883.

Wich, D. (2009). Project Scope Management. 17, 2-6.

Wieggers, K. (2000). *Symptoms and solutions for requirements-related project problem*. Retrieved from [www.cs.nott.ac.uk: www.cs.nott.ac.uk/jds/teaching/archive/RequirementsTraps.pdf](http://www.cs.nott.ac.uk/jds/teaching/archive/RequirementsTraps.pdf)

Williams, B., Vaughn, R., & Williams, P. (2006). Change Risk Assessment: Understanding Risks Involved in Changing Software Requirements. *International Conference of Software Engineering*, (pp. 966-971).

Williams, S. (2006). *Requirement Volatility and its impact on change effort: Evidence based research on software development project*. University of South Australia.

Winuk, K., Gorschek, T., & Callele, D. (2016). Supporting Scope Tracking and Visualization for Very Large-Scale Requirements Engineering-Utilizing FSC + , Decision Patterns , and Atomic Decision Visualizations. *IEEE*, 42, 47-74.

Wnuk, K., Regnell, B., & Karlsson, L. (2008). Visualization of Feature Survival in Platform-Based Embedded Systems Development for Improved Understanding of Scope Dynamics. *2008 Requirements Engineering Visualization* (pp. 41-50). IEEE.

Wohlin, C., & Andrews, A. (2001). Assessing Project Success Using Subjective Evaluation Factors. *Software Quality Journal.*, 9, 43-70.

Xia, B., Xiong, B., Skitmore, M., Wu, P., & Hu, F. (2015). Investigating the impact of project definition clarity on project performance: structural equation modeling study. *Journal oof Management Engineering*.

Zaneldin, E. (2005). Construction claims in the United Arab Emirates: causes, severity, and frequency”, . *The Sixth Annual UAE University Research Conference*, (pp. 96-105). UAE.

Zowghi, D., & Nurmullani, N. (2002). A study of the impact of requirements volatility on software project performance. *Asia Pacific Software Engineering Conference* (pp. 3-11). IEEE.

ANNEX I - INTERVIEW GUIDELINE

1. Aim of the study –

2. This research aims to investigate on the Impact of indeterminacy of scope definition on Iron Triangle performance in Public Construction Projects.

3. Objectives of the study-

- Critically review the phenomena of indeterminacy of scope definition in the context of construction projects
- Identify the causes behind the indeterminacy of project scope definition in Public Building Projects
- Develop strategies to minimise the impact of indeterminacy of project scope definition on Iron Triangle performance in public sector projects.
- Appraise the impact of indeterminacy of project scope definition on Iron Triangle Performance in public building projects

4. Details of Respondent

- ❖ Profession:
- ❖ Designation:
- ❖ Number of years of experience in the Construction Industry:
- ❖ Number of years of experience in Public Building Projects:
- ❖ Date:
.....
- ❖ Case Code:

5. General Perception

- ❖ What are the special features of Public Building Projects compared to other construction projects?
.....
.....
.....

.....

.....

.....

6. Select the causes for above case from the list below?

No	Causes for Changes in Scope	Applicability for the Case
1	Project Priority	
2	Lack of Motivation and Decision	
3	impractical design	
4	labor shortages	
5	Project Risk	
6	Quality Issue	
7	Lower Productivity	
8	Failure to reach customer expectations	
9	Poor effort estimation	
10	Increase effort	
11	Slow down project Progress	
12	poor performance	
13	unforeseen conditions	
14	technological uncertainty	
15	Unclear	
16	Change Cost	
17	Project Resources	
18	Error generation rate	
19	Poorly Written	
20	Effort wasted	
21	Project Failure	
22	Lack of Clarity	
23	scopes may be ambiguous	
24	Changes in Legislations	
25	Changes in regulatory	
26	Client Change	
27	Rework	
28	Delays in Schedules	
29	Lack of Concentrate on defining scope	
30	Communication and Coordination Gaps	

7. What are the additional causes according to your opinion for the above case?

.....

.....

.....

.....

.....

8. Select the proper scope management strategies for above case from the list below?

No	Scope Management Strategy	Applicability for the Case
1	Identify requirements properly	
2	Identify Stakeholders	
3	Identify Project Drivers	
4	Examine the Scope Statement	
5	Queuing Theory - reducing the impact of waiting periods of critical work packages	
6	considerations of time	
7	Communicate what to do and how to deliver the results	
8	Identify both activities and results	
9	Consolidate requirements	
10	Consideration of budget	
11	Complete prevention of a scope	
12	project manager needs to be vigilant	
13	Facilitate the assignment of roles and responsibilities	
14	Avoid the omission of tasks and their duplicity	
15	Guide the realization of both budget and schedule	
16	Document learned lessons	
17	Reference improvement processes	
18	understand the client's vision properly	
19	Be unambiguous	
20	Be accurate	
21	Take both preventive and corrective actions	
22	Analyse requested changes impact, studying its conditions and traceability	
23	Influence factors that cause scope changes	
24	Prescriptions for client change.	
25	Prescriptions for unforeseen risks	

No	Scope Management Strategy	Applicability for the Case
26	Prescriptions for unclear scope	
27	Define both work and deliverables	
28	Analyse requirements providers	
29	Study agreed requirements impact	
30	Examine assumptions and constraints	
31	Consideration of specification	
32	Consideration of customer satisfaction	
33	maintaining status quo within the organization.	
34	Include both intermediate and final deliverables characteristics, specifications and acceptance criteria, preliminary cost estimates and schedule milestones	
35	Integrate changes control	
36	Facilitate impact analysis and communication	
37	Measure performance	
38	Identify variations	
39	Get a formal acceptance	
40	Review deliverables	
41	Ensure agreed changes are properly processed	

9. What are the additional management strategies according to your opinion for the above case?

.....

.....

.....

.....

.....

10. Additional Comments for improve the study?

.....

.....

.....

Thank You

ANNEX II - QUESTIONNAIRE

1. Aim of the study –

This research aims to investigate on the Impact of indeterminacy of scope definition on Iron Triangle performance in Public Construction Projects.

2. Objectives of the study-

- Critically review the phenomena of indeterminacy of scope definition in the context of construction projects
- Identify the causes behind the indeterminacy of project scope definition in Public Building Projects
- Develop strategies to minimise the impact of indeterminacy of project scope definition on Iron Triangle performance in public sector projects.
- Appraise the impact of indeterminacy of project scope definition on Iron Triangle Performance in public building projects

Designation				
Profession				
Experience in Construction Industry	☐ 1-5	☐ 5-10	☐ 10-15	☐ 15-20
	☐ 20-25	☐ more than 25		
Experience in Public Building Projects	☐ 1-5	☐ 5-10	☐ 10-15	☐ 15-20
	☐ 20-25	☐ more than 25		

3. Rank the following causes according to the impact on iron triangle for each section. Please refer to the scale given below.

- 1 – Very Low Impact
 2 – Low Impact
 3 – Average Impact
 4 – High Impact
 5 – Very High Impact

No	Causes for Scope Changes	Impact on Iron Triangle														
		Impact on Time					Impact on Cost					Impact on Quality				
1	Less Project Priority	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
2	Lack of Motivation and Decision	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
3	impractical design	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
4	Project Risk	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
5	Quality Issue	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
6	Fialure to reach customer expectations	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
7	Poor effort estimation	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
8	Increase effort	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
9	Poor performance	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
10	Unforeseen conditions	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
11	Technological uncertainty	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
12	Unclear scope	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
13	Change Cost	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
14	Poorly Written	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
15	Lack of Clarity	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
16	Scopes may be ambiguous	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
17	Changes in Legislations	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
18	Changes in regulatory	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
19	Client Change	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
20	Lack of Concentrate on defining scope	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
21	Communication and	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤

No	Causes for Scope Changes	Impact on Iron Triangle														
		Impact on Time					Impact on Cost					Impact on Quality				
	Coordination Gaps															
22	Lack of end-user inputs during the design stage	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
23	poor coordination between the other relevant authorities	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
24	Design deficiencies	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
25	Poor Decision Making	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
26	Lack of Planning	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
27	Political Influences	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤

Thank you.