Time and Cost Overrun Analysis and Mitigation Procedures in Construction Projects

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ABSTRACT

Upon the completion of large national construction projects, their cost and time deviations are often reported. These deviations from the projected values are a result of complications in the time and cost management of such projects. Controlling the cost and time overrun of projects is important for successful implementation and efficient project management. However, few studies have attempted to measure the project cost and time management efficiency in civil engineering projects.

In this research, sixty-three large construction projects, which were financially supported by Asian Development Bank (ADB) and government of origin countries that had cost and time difficulties were carefully investigated and configured as Decision Making Units (DMUs) in a Data Envelopment Analysis (DEA) method. Meanwhile a list of associated causes leading to cost and time deviations and percentage of cost and time overrun for each DMU were extracted and provided. The management efficiency of DMU's was calculated by DEA method and outputs were ordered. The identified results demonstrate that "delay in mobilization by contractor", "design changes", "poor project management and supervision" and "severe weather condition" are the four important frequent causes that critically influence the time management performance of projects. Meanwhile "fluctuations and escalations in the prices of material, equipment and labor", "change in exchange rate", "underestimated and inaccurate appraisals" and "increase in the land acquisition price and compensation" have the most influence on cost management efficiency score respectively. Moreover "additional works", "inaccurate initial project scope", "increase or change in the scope of the project", and "design changes" are four

common critical causes that strongly impact both time and cost management efficiency. Furthermore, a sensitivity analysis with the aim of study the importance of frequent causes of time and cost overrun that influence time and cost management performance was performed. According to the results of sensitivity analysis, “design changes”, “delay in mobilization by contractor” and “poor project management, construction management and supervision” have greater influence on time management efficiency. Likewise, results showed that, “underestimated and inaccurate appraisals”, “changes in the exchange rate” and “increase in quantity of works” are the critical causes that cost management performance is more sensitive to them.

The first objective of this research is to compare efficiency of different DMU’s regarding to different causes resulting time and cost overrun and mark the causes which critically reduce the management efficiency of large construction projects regarding time and cost aspects. The Second aim is to provide a guide for policy and decision makers in ADB, construction related ministries of governments, contract related units, project managers and contractor companies to pay more attention to the probable problems that may arise and affect the efficiency gaps of those types of projects. This guide is provided through identification roots of each adverse cause, its consequences and recommendations about how to prevent and in which way consequences might be mitigated. Another objective of this dissertation, is developing a website as a knowledge dissemination tool based on the provided data in previous sections for the use of construction practitioners as a decision support system.

Keywords: Delay, Time overrun, Cost overrun, Data Envelopment Analysis, Mitigation Measures

ÖZ

Büyük ulusal inşaat projelerinin tamamlanması üzerine, maliyet ve zaman sapmaları sıklıkla rapor edilir. Öngörülen değerlerden bu sapmalar, bu tür projelerin zaman ve maliyet yönetimindeki komplikasyonların bir sonucudur. Başarılı uygulama ve verimli proje yönetimi için projelerin maliyet ve zaman aşımını kontrol etmek önemlidir. Bununla birlikte, inşaat mühendisliğinde proje maliyetini ve zaman yönetimi verimliliğini ölçmek için çok az çalışma yapılmıştır.

Bu araştırmada, Asya Kalkınma Bankası (ADB) ve maliyet ve zaman zorluğu yaşayan menşe ülke hükümeti tarafından mali olarak desteklenen altmış üç büyük inşaat projesi, Veri Zarflama Analizinde (DEA) Karar Verme Birimleri (DMU) olarak dikkatle araştırılmış ve yapılandırılmıştır. Bu arada, maliyet ve zaman sapmalarına yol açan ilişkili nedenlerin bir listesi ve her DMU için maliyet ve zaman aşımı yüzdesi elde edildi. DMU'ların yönetim etkinliği DEA yöntemi ile hesaplanmıştır. Tespit edilen sonuçlar, "yüklenici tarafından mobilizasyonda gecikme", "tasarım değişiklikleri", "kötü proje yönetimi ve denetimi" ve "şiddetli hava koşulları" nın, projelerin zaman yönetimi performansını kritik olarak etkileyen dört önemli neden olduğunu göstermektedir. Öte yandan, "malzeme, teçhizat ve işçilik fiyatlarındaki dalgalanmalar ve yükselişler", "döviz kurundaki değişim", "düşük keşif ve yanlış değerlendirmeler" ve "arsa edinim fiyatındaki ve kamulaştırmalardaki artış" maliyet yönetimi verimlilik puanı üzerinde en fazla etkiye sahiptir. Ayrıca "ek işler", "proje kapsamında yanlış belirlemeler", "proje kapsamındaki artış veya değişim" ve "tasarım değişiklikleri" hem zaman hem de maliyet yönetimi verimliliğini güçlü bir şekilde etkileyen dört ortak kritik nedendir.

Ayrıca, zaman ve maliyet yönetimi performansını etkileyen sık sık zaman ve maliyet aşımının önemini incelemek amacıyla duyarlılık analizi yapılmıştır. Duyarlılık analizi sonuçlarına göre, “tasarım değişiklikleri”, “yüklenici tarafından mobilizasyonda gecikme” ve “kötü proje yönetimi, inşaat yönetimi ve denetimi” zaman yönetimi verimliliği üzerinde daha fazla etkiye sahiptir. Benzer şekilde, sonuçlar “düşük keşif ve yanlış değerlendirmeler”, “döviz kurundaki değişiklikler” ve “iş miktarındaki artış” maliyet yönetimi performansının kendilerine daha duyarlı olmasının kritik nedenleri olduğunu göstermiştir.Bu araştırmanın ilk amacı, farklı DMU'ların zaman ve maliyet aşımına neden olan farklı nedenlerle ilgili verimliliğini karşılaştırmak ve büyük inşaat projelerinin zaman ve maliyet yönlerinde yönetim verimliliğini önemli ölçüde azaltan nedenleri işaretlemektir.

İkinci amaç, ADB'deki politika ve karar vericiler, hükümetlerin inşaatla ilgili bakanlıkları, sözleşmeyle ilgili birimler, proje yöneticileri ve yüklenici şirketler için ortaya çıkabilecek olası sorunlara daha fazla dikkat etmeleri ve bu türlerin verimlilik boşluklarını etkilemeleri için bir rehber sağlamaktır. Bu kılavuz, projelerde her bir olumsuz nedenin tanım kökenlerini, sonuçlarını ve nasıl önleneceğini belirtip, sonuçların hangi yollarla azaltılabileceği ile ilgili öneriler sağlamaktadır.

Bu tezin bir diğer amacı, inşaat uygulayıcılarının karar destek sistemi olarak kullanılması için önceki bölümlerde sağlanan verilere dayanan bir bilgi yayma aracı olarak bir web sitesi geliştirmektir.

Anahtar Kelimeler: Gecikme, Zaman taşması, Maliyet taşması, Veri Zarflama Analizi, Etki azaltma önlemleri

To my loving parents who supported me all the way hoping that I made them proud

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
AFDB	African Development Bank
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
FIDIC	Fédération International des Ingénieurs-Conseils
KM	Knowledge Management
PCR	Project Completion Report
PIM	Performance Improvement Management
RII	Relative Importance Index
UNECE	United Nations Economic Commission for Europe
WB	World Bank

Chapter 1

INTRODUCTION

1.1 Background

Significant share of any country's economy goes to construction sector and it delivers important influences for the growth of economy (Ahbab & Celik, 2012). The construction sector is an essential part of the economy for each country and has a significant impact on other industries' performance and products. It is unlikely to have significant investment in other industries such as service, industrial or agricultural sectors by considering no building of large-scale facilities in place (Erol & Unal, 2015).

Output from this industry is the main and essential portion of the national output of countries, accounting for a considerable percentage in the Gross Domestic Product (GDP) of developed and even developing countries.

The United Nations Economic Commission for Europe (UNECE) revealed that the portion of construction sector in GDP was equal to18% in United States, 9.7% in Turkey and 6% in United Kingdom in year 2016 (UNECE, 2019).

Coherently, construction sector has unique structures that do not typically occur. Constructing large constructions are unique and generally difficult, lengthy and absorbs a large sum of investment.

As a matter of the fact, circumstances tend toward being more complex than what is expected in planning and design phase, therefore additional costs and time are required. On the other hand, output of construction industry is not always completed as it is planned owing to presence of real adverse conditions, large sum of activities, variation in terms of scope, objectives, duration and presence of different parties involved in the project.

Attain to the completion of any project is no longer accepted as an achievement for the project's owner. Success of a project depends on many criteria. The most important and common criteria is completion of the project according to the stated authorized time and cost in contract. Projects should be completed within the authorized budget and time without any postponement or suspension of works and with minimum amount of problems. The most realistic approach to this issue has been designated by Gunduz et al. in their research in the literature. They summarized their findings by indicating that if the project meets its time, cost and quality objectives and realize interested parties fulfillment, it is considered as a successful construction project (Gunduz, Nielsen, & Ozdemir, 2013).

Numerous researchers (Refer to Appendix1) endorsed that most of construction projects experiences time and cost overrun at the delivery point. This means that significant amounts of liquidity and time for governments and corporations are wasted by mismanagement and execution. The above mentioned problems arising from some of the time and cost adverse causes which some of them are distinguishable or the rest may be totally unanticipated. Many of those researchers also investigated those causes, published a short list of them and their consequences including time and cost overrun. Accurate identifying, defining and understanding of the critical causes that affect the

important performance measures of construction projects is still a large area of investigation across the world.

In order to accomplish the construction projects within cost and timely as planned in the schedule, a continuously improvement in performance of project managers is required. Gridhar and Ramesh stated that project management is a combination of workers, engineers, equipment, materials, manpower and undertaken methods (Giridhar & Ramesh, 1998). Frimpong et al. indicated that some projects are effectively and efficiently managed whereas some others are managed poorly and lead projects to time and cost overrun (Frimpong, Oluwoye, & Crawfordc, 2003). As a result, a blameless project management includes the management tools and methods that carry out to manage and reach to objectives of the project in contract. It can be concluded that project manager's performance measurement is essential to be done. It would increase the efficiency of project managers and accordingly success of their company by avoiding failures.

Project Management Efficiency can be defined as the amount of success attained at the end of project. In terms of time and cost management, it can be well-defined as the amount of success of project managers in reaching to timely and within the budget.

Performance measurement can be computed through Data Envelopment Analysis (DEA) method. It is a nonparametric modern mathematical tool for measuring and determining the efficiency and efficient projects which configured as Decision Making Units (DMUs) respectively.

Aforementioned measuring will help to improve the efficiency of project managers through the continuously evaluation and recognizing adverse cause affecting the efficiency. In the light of performance measuring, adverse causes that have more impact on the performance of investigated DMUs can be recognized. Accordingly, the countermeasures and mitigation techniques for the succeeding projects can be adopted in advance with the help of knowledge management and lessons learned. The procedure of identification of the causes and proper resolve techniques including countermeasures and mitigation methods as an in depth research should be seriously followed till ensuring that the adverse causes are not a foundation for time and cost overrun or they have the minimum effect on total budget and schedule of projects.

1.2 Problem Statement and Research Justification

Generally, projects have difficulties in coordination and management of the construction in addition to constraints of resources, cost and schedule. Failure to finish the projects timely and within the predefined cost is an essential problem. In most of construction projects, experiencing time and cost overrun is a common problem.

Failure to reach to one or some of the objectives of a project like to be within the estimated cost is a common phenomenon. Practically, cost overrun is a usual incidence, which occurs in most of the projects in construction sector. In developing countries, cost and time overrun is much more significant, while those overruns sometimes go higher than half of the expected total cost. In Turkey, it is reported that in the “state and provincial roads project”, the total cost at completion, was about 56.4% higher than the estimated cost (The World Bank, 1998).

Time overrun is one of the most frequent, major and important problems that impacts the time criteria of the construction projects. In spite of the fact that technological improvements and achieving to enhanced project management techniques by project administrators and supervisors, still delay is a significant criterion. There are dissimilar causes for time overrun in the construction projects. There are numerous types of causes influencing the time of the projects and lead to delays. More or less delays make the situation even more difficult and complex (Ahbab & Celik, 2012).

The results of first important research on the adverse causes of cost overrun in 258 transport infrastructure projects in 20 countries published by Flyvbjerg et al. showed that cost overrun is a global problem (Flyvbjerg, Skamris Holm, & Buhl, 2003). Endut et al. investigated time and cost criteria in 359 public and private construction projects in Malaysia. They conclude that time overrun is much more significant than cost overrun in Malaysian construction sector. Based on their investigation cost overrun has the same pattern in both public and private sectors. They reported that less than 50 percent of the projects were successful in terms of budget. In terms of time, their result shows that over 2/3 of studied projects were not accomplished timely (Endut, Akintoye, & Kelly, 2009). Ahsan and Gunawan inspected and analyzed the cost and time variation of 100 international development projects. They identified the major causes of time extension and cost overrun (Ahsan & Gunawan, 2010).

Multiplicity of different research and investigations undertaken by various researchers over the time and cost overrun clearly shows the significance of identifying causes as given in appendix1. This also verifies the actuality of issues relative to cost and time criteria in construction projects leading to time and budget overrun.

Therefore, it is vital to realize and focus on the main causes that impacting the performance of time and cost management criteria and do more in depth investigations. By the mean of this investigation and through better understanding of the causes, countermeasures and mitigation measures can be defined well. On this direction Olawale and Sun proposed the mitigation measures for 5 significant adverse causes in their area of study. Nevertheless their investigation was limited to those causes and each one may have different level of impact in other countries and regions or in public and private sectors (Olawale & Sun, 2010).

In order to justify the research of this thesis, it was focused on the evaluation of the records from ninety-one large construction projects that were not finished on time and/or within the specified total cost in contracts. It was concluded that, time and cost overruns are still a problem of construction industry that needs to be investigated further.

Currently, poor and inefficient performance of project managers in time and cost management criteria is a major adverse reason in finishing the construction projects.

Adverse causes are still presenting themselves as key problems in construction projects. Despite of presence of several researches and lessons learned from former projects, still time and cost overrun threaten the construction projects. Therefore, the mitigation issues of this problem seems to be vital.

1.3 Research Questions

According to the statement of the problem and with the aim of attaining a concrete, practical and sound conclusion, current research was established to answer the following question.

How it is possible to increase time and cost management efficiency in construction projects through identifying major time and cost overrun adverse causes and proposing preventive and mitigation measures for them by applying knowledge management tools.

1.4 Scope and Objectives of the Research

Construction industry has an undeniable effect on economy of countries. Due to this reason in this study especially large construction projects in terms of budget were selected.

Generally, contractors keep the project data confidential. Therefore, in this study, Project Completion Reports (PCRs) published by Asian Developing Bank (ADB), African Developing Bank (AFDB) and World Bank were selected to provide the data. In this study, the investigated projects were limited to those that experienced time, cost or both overruns.

Within the above mentioned defined scope, objectives of this research are given as below:

1. To investigate adverse causes on time and cost criteria of the construction projects;

2. To identify the consequences of the investigated causes in construction projects;
3. To investigate the awareness of construction practitioners on time and cost criteria in construction projects recently;
4. To investigate the existence of research on the measurement of the efficiency or time and cost management performance of the project managers in construction industry;
5. To obtain the most critical causes affecting time and cost management performances of the project managers by using Data Envelopment Analysis (DEA) computing method;
6. To obtain the relationship between time and cost management performance in construction projects as output of DEA and sensitivity analysis;
7. To specify recommended countermeasures against critical adverse causes;
8. To evaluate the required and recommended mitigation measures to mitigate the effect of critical adverse causes;
9. To develop a webpage in order to improve the time and cost management performances of project managers.

1.5 Research Methodology

Consistent with above-mentioned scope and objectives, current investigation contains of the followings. In the initial phase, an investigation to identify and understand the main adverse causes that affecting schedule and cost of the construction projects and lead them to time and cost overrun was performed. This part of the study was made up of two steps. In the first step a literature review on the relevant available scientific articles was done. Thereafter a study on obtained and selected PCR documents published by World Bank (WB), ADB and AFDB was carried out and used as

secondary data. Based on the abovementioned steps the reality of time and cost problems in projects were justified. Moreover, dissimilar adverse cause with unfavorable effects on construction projects were identified, extracted and tabulated.

In the next phase of this study, results of the study were ordered with respect to their relative importance index (Ahbab, 2012) and their frequency of occurrence and a data set were developed. Generated set of data were modeled for each of time and cost criteria using the Performance Improvement Management software (PIM-DEA) to do Data Envelopment Analysis (DEA). (Emrouznejad, Ali; Thanassoulis, Emmanuel;, 2017). Results of the analysis demonstrates the time and cost management performance as efficiency score for each of studied project. Projects were ordered based on their relative efficiency score in time and cost management criteria separately. Afterward a sensitivity analysis on adverse causes of inefficient projects were applied to quantify their importance.

In the last phase of the current investigation, corrective actions and mitigation measures to deal with adverse time and cost causes were suggested and published as a website and a construction management aid CD.

1.6 Research Novelty and Contribution

An assessment of the performance of project managers as time and cost management efficiency over the selected case studies were done. To the best knowledge of author that there is no research have investigated and computed the managerial efficiency of project managers on time and cost criteria in construction industry which can be considered as a gap. The applied methodology can be contributed as an instrument to measure time and cost management efficiency.

Another significance of current study would be the published website and the developed construction time and cost management kit as a useful and practical guide for construction managers.

1.7 Achievements

According to the preformed investigation on large transportation projects, questionnaires and interviews with construction practitioners and obtained analysis results, following achievements were achieved:

1. Survival of delay and cost issues in the large construction projects is proved;
2. Identification of main roots of delay and budget overrun in large construction projects;
3. Identification of severity of the affecting causes of time and cost;
4. Identification of causes that severely affecting time and cost management efficiency;
5. Identification of roots of adverse causes of time and cost;
6. Identification of consequences of adverse causes;
7. Recommendation of preventive actions to oppose adverse causes before occurrence;
8. Recommendation for taking mitigation measures and required corrective actions to oppose adverse time and cost causes;
9. Developing a website for use of project managers and construction practitioners.

1.8 Structure of the Thesis

Current thesis is divided and organized into eight chapters.

Chapter one comprises of background, problem statement and research justifications, research questions, aims and objectives, scope and limitations of the research, research methodology, research novelty and contribution, and achievements.

Chapter two includes a literature about the concepts of project management, project manager, cost and time management and a review on the works done with the subject of time and cost overrun in construction industry.

Chapter three explains the works and approaches done to reach to the objectives of the current research. In the other word, it includes full and illustrative description about data collection, questionnaire, and how different types of analysis were done.

Chapter four includes a brief summary of case studies including objectives of large construction projects and their basic cost and time data.

Chapter five introduces the DEA as a useful tool for measuring the performance and its mathematical forms and procedure.

Chapter six focuses on obtained results of the different analysis in this investigation. In the other word, discussions on the results in direction with the objectives of this research are provided.

Chapter Seven includes the Mitigation procedures.

Chapter Eight includes basic information about the developed and designed website for the use of project managers

Chapter Nine is a summary of the current investigation including key findings, conclusions and recommendations.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

Nowadays, construction industry plays a significant role in the flow of world global economy. A considerable amount of domestic liquidity of countries belongs to the construction industry. (Ahbab & Celik, 2012) Simultaneously with the economic development of the countries, implementations of large civil engineering construction projects are increasing. Therefore, successful implementation of these projects are particularly important. Achieve to an end within defined scope and objectives in contract like total duration and authorized completed cost is one of the most important and obvious expectancy of clients. This accomplishment should be leaded and done by project managers to prevent time and cost overrun.

In this chapter, an in depth literature survey in line with the aims and objectives of this research is performed to help identification and assessment the categories, causes of time and cost overrun, time and cost management performance and approaches for taking preventive and corrective actions for delay and cost overrun.

2.2 Definition of Cost Overrun in Construction Projects

Authorized cost in contract of construction projects and final cost of project are strongly in relation with each other. Written amount in contract is agreed and signed by client and contractor of project. Any deviation in agreed amount of project or exceed amount after completion of project is cost overrun or budget overrun. There

are numerous studies on cost performance of construction projects. Most of these researches reporting cost overrun as a common problem in construction projects. For instance Cheng in his study indicates cost overrun as a typical issue of construction projects (Cheng, 2014).

Cost increase or cost overrun is defined as “Amount by which the actual cost exceeds the budgeted, estimated, and original or target cost” (Businessdictionary, 2019). Christensen and Gordon defined cost overrun as the difference between the budget for the finishing the project and the actual cost of the finished work (Christensen & Gordon , 1998). In another research cost overrun was defined as “the amount by which actual costs exceed the baseline or approved costs” (Danso & Antwi, 2012). Sweis et al. described cost as an important part of construction projects. They also indicated that budget overrun is a common frequent problem in construction industry (Sweis G. J., Sweis, Abu Rumman, Hussein, & Dahiyat, 2013). In another research cost overrun defined as a budget increase, cost increase, or cost growth (Love, Sing, Carey, & Kim, 2015). Katre and Ghaitidak defined cost overrun as excess of final cost of project over contracted amount. They also mentioned that for comparison purposes result of this calculations can be converted to percentage (Katre & Ghaitidak, 2016).

2.3 Definition of Time Overrun in Construction Projects

Time of the project is an important criteria on any construction projects. Due to the natural nature of projects in each contract, the start and end dates of the project are specified. Time of contract or time of project can be defined as the utmost duration authorized for the contractor to finish whole the project not later than the agreed duration in contract documents. Any deviation in agreed implementation schedule and change in the completion date of project is called delay or time overrun or schedule

overrun. It also can be defined as difference in between actual date of completion and expected date for finishing the project in contract. Project delay can be explained as implement later than anticipated plan, or specific period, or later than particular time that all the involved parties agreed for construction of the project. Time overrun is defined as the addition of time beyond planned finishing date observable to the project contractors (Kaming, Olomolaiye, Holt, & Harris, 1997). A delay is an action or incident that prolongs the time necessary to perform tasks written in a contract (Stumpf, 2000). In another research, delay was defined as "the time overrun either beyond completion date specified in a contract, or beyond the date that the parties agreed upon for delivery of a project" (Assaf & Al-Hejji, 2006). According to Danso and Antwi delay is a general problem that causes financial and time concerns (Danso & Antwi, 2012).

2.4 Causes of Cost Overrun

The research on identifying origin and degree of impact for responsible causes that negatively affect the performance of Civil Engineering projects has been given considerable attention by researchers over the past three decades. In line with this, one of the typical and important part of these investigations is the budgeting and cost criteria of construction projects. These efforts demonstrate and validates the importance of attention to well identify adverse cost causes which leads the construction projects into budget overrun. Numerous scholars have performed studies on the issue of construction cost overrun with the aim of identify the causative factors.

One of the first investigations to identify causes of cost overrun was done on high-rise construction project's data in Indonesia by Kaming et al. In order to identify important causes of cost overrun, investigators performed a questionnaire and ranked the causes

based on their observed importance and frequency. It is indicated that fluctuations in cost of materials, incorrect material estimating and project complexity are the main reasons of cost overruns (Kaming, Olomolaiye, Holt, & Harris, 1997).

An investigation carried out by Flyberg et al. among 258 projects summarized that 90% of infrastructure transport projects experiences cost overrun. They also calculated average rate of cost overrun for different types of investigated projects for rail, fixed links and road projects as 45%, 34% and 20% respectively (Flyvbjerg, Skamris Holm, & Buhl, 2003).

In another study, causes of cost overrun were identified and ranked through interview with 450 private residential project clients. Obtained results indicated that contractor related, material related and, owner financial difficulties were the most three important causes of cost overrun in Kuwait (Koushki, Al-Rashid, & Kartam, 2005).

Affecting causes of cost performance in Indian construction industry was studied by Iyer and Jha. Fifty-five identified success and failure attributes by literature and by person interviews formed a questionnaire and the factor analysis results showed that:

1. Conflict between project contributors;
2. Unawareness and lack of knowledge;
3. Presence of poor project specific attributes and nonexistence of teamwork;
4. Hostile socio economic and climatic circumstance;
5. Unwillingness to make timely decision;
6. Short bid preparation time-

-are the most significant causes that affect cost performance of projects (Iyer & Jha, 2005).

The most significant ten causes of cost overrun in Pakistan was identified and reported by Azhar et al. in an investigation. The most ten critical causes of cost overrun was identified by the mean of literature review, conduction and analysis of a questionnaire results (Azhar, Farooqui, & Ahmed, 2008):

1) Increase in price of raw materials;
2) Unstable price of factory-made materials;
3) High cost of equipment;
4) Lowest bidding procurement methods in selection of contractor;
5) Poor cost and project management;
6) Long time in between design and procurement stage;
7) Incorrect or unsuitable techniques of cost prediction;
8) Increase in the amount of works;
9) Inappropriate planning;
10) Obstructive government policies.

Another investigation was carried out in Ethiopia to identify responsible causes for cost overrun and assess the effects of them on construction projects. According to the obtained results, about 95% of studied projects was suffering from cost overrun. Inflation or fluctuations in cost of construction materials, weak planning and management, frequent change orders by owners to enhance project and excess quantity in the period of construction was identified as the most important causes of cost overrun. Delay was also introduced as the most important consequences of cost overrun (Nega, 2008).

By an in depth literature review and interviews, Shane et al. identified eighteen causes that impact the initial budget of projects and categorized them. They classified cost

escalation causes as controllable or internal and non-controllable or external causes. For instance changes in schedule of project, complexity of engineering project and poor predictions were classified as internal causes where effects of fluctuations in prices or inflation, unforeseen events and unforeseen conditions were classified as external (Shane, Molenaar, Anderson, & Schexnayder, 2009).

Kaliba et al. established another study to identify important causes of time and cost overrun in Zambia. They aimed to identify adverse causes by conduction of questionnaire, structured interviews and literature review. They reported that:

1) Bad or severe weather condition due to heavy rainfall and floods;
2) Change in scope of the project,
3) Environmental protection and mitigation expenses;
4) Delay in schedules;
5) Strikes;
6) Technical requirements and challenges;
7) Cost escalation on the prices or inflation;
8) Pressures exerted by local Government

were the main causes of cost overrun in Zambia's road construction projects (Kaliba, Muya, & Mumba, 2009).

Main three blamable causes out of forty two causes of cost overrun comprised of increase the cost of construction materials, delays in on-time supply of materials and transport equipment to the construction site and inflation was reported by Enshassi et al. as a result of investigation on construction projects in the Gaza Strip (Enshassi, Al-Najjar, & Kumaraswamy, 2009).

In one of the most comprehensive researches on this area, Olawale et al. identified critical causes that prevent proper time and cost control and management in United Kingdom. Identification were done by conduction a survey on two hundred fifty construction organizations following by interviewing to fifteen of them. According to the obtained results in this research:

1) Changes in designs;
2) Risk and uncertainty related to projects;
3) Inaccurate assessment of projects implementation duration;
4) Poor performance of subcontractors and suppliers;
5) Complexity of works;
6) Problems between project parties;
7) Differences in contract documents;
8) Contract and specification understanding disagreement between parties;
9) Fluctuation of prices or inflation

were the most significant causes that inhibit effective cost management (Olawale & Sun, 2010).

In another investigation by Enshassi et al. identification of causes impacting cost and time of construction projects in Gaza Strip was aimed. Forty-two causes of cost overrun were input in a questionnaire and distributed to general contractors to give their views. After analyzing the responses of contractors by Relative Importance Index (RII) method, causes were ranked accordingly. Based on the obtained results, rank of the causes are as followings:

1) Fluctuation of material prices owing to border closings,
2) Slow progress of construction phase,

3) Supply of necessary resources like equipment and materials by contractors,
4) Instabilities and rising in the cost of construction materials,
5) Materials monopoly by dealers,
6) Variability of the exchange rate versus dollar,
7) low obligation of contributors to compensate any negative outcomes attributable to the economic and political conditions,
8) Awarding project to the lowest offered price by contractors.

They recommended presence of contingency plans in contract and better project management methods to overcome these causes (Enshassi, Kumaraswamy, & Al-Najjar, 2010).

In a study conducted in Malaysia, Memon et al. reported that financial problems of contractor, Poor construction site management by contractor, poor experience of contractor, dearth of workers in construction site and improper planning and scheduling by contractor are most severe factors that affecting construction sites. Unlike other investigations by researchers, in this investigation, it is stated that scope changes and frequent design changes had not significant impact on cost of their studied construction projects (Memon, Abdul, Abdullah, Asmi, & Azis, 2010).

In Malaysia, Memon et al. identified seventy-eight different causes of cost overrun by a comprehensive literature review and interview with experts in construction industry to discover the significance of studied causes. According to the obtained results, they stated that defective design and consume too much time for design, impractical contract period, Poor experience of contractor, delay in delivery of equipment and construction materials into the site of project, interrelation of management team and

labors, delay in preparation of drawings and confirmation, poor planning and scheduling, poor site management and supervision and errors in construction phase were most important and main causes of cost overrun (Memon, Rahman, & Abdul Azis, 2011).

Cost overrun causes in Ethiopian federal road construction projects were studied by Wakjira in 2011. In this investigation, it is reported that 80% of studied projects were a victim of cost overrun. Unanticipated increase in prices of materials, delay on commissioning the project, change in scope of the project, unstable cost of factory-made materials, insufficient site exploration and right of way problems were stated as the key causes of cost overrun (Wakjira, 2011).

Sweis et al. identified the main causes of cost overrun in Jordan based on two sets of results of questionnaire and secondary data provided by Ministry of housing and public works relating to fifty-seven public projects. Among critical cost causes, design changes are reported as common cause. Governmental delay and severe climate condition was also reported as two other major causes of cost overrun according to the results of secondary data (Sweis G. J., Sweis, Abu Rumman, Hussein, & Dahiyat, 2013).

In another investigation carried out by Subramani et al., major causes of cost overrun were identified and analyzed by the mean of literature review and questionnaire survey. Thereafter causes were ranked based on obtained frequency of occurrence and severity impact. According to results of investigation:

1) Long duration of decision making by decision makers;
2) Poor time-plan management;

3) Price fluctuations of material or equipment;
4) Ineffective contract management,
5) Poor design or late submission of designs,
6) Rework owing to erroneous or mistaken work,
7) Difficulties in land acquisition process,
8) Poor or incorrect estimation;
9) Long time between design and time of tendering process

were the main causes of cost overrun in India (Subramani, Sruthi, & Kavitha, 2014).

Assessing the causes that influencing cost of construction projects in India was done by Katre and Ghaitidak2. As a result of this investigation, delay in initial handing over the construction site to contractor, delay in delivery of materials and equipment to site area by contractor and inflation was reported as the main causes of cost overrun in studied projects (Katre & Ghaitidak, 2016).

Wanjari and Dobariya investigated the causes of cost overrun in India. They reported that increase in price of raw material, delay in implementation of planned activities and absence of coordination between constructions parties are the main three causes of cost overrun in their pool of study (Wanjari & Dobariya, 2016).

In another study, identification of causes responsible for cost overrun in India were investigated by Patil and Bhangale. According to opinion of Indian clients, consultants and contractors as respondents of a structured questionnaire formed of different causes of cost overrun, the major causes of cost overrun were reported as expensive transportation costs, change in description of materials, fluctuation of material prices,

repeated failure of construction plants and equipment, and rework (Patil & Bhangale, 2016).

In Pakistan, Sohu et al. stated that cost overrun in freeway projects is a global common phenomenon. They focused on identification of causes of cost overrun as the main objective of their research. A questionnaire was developed based on sixty-four causes of cost overrun obtained from literature and shortlisted. Results of questionnaire was analyzed and:

1. Slow payment procedure or delay by client;
2. Insufficient planning by contractor;
3. Interfering of client;
4. Poor management of contract;
5. Delay of decision making process by owner;
6. Scope change;
7. Financial problems of owner

were stated as the most significant of cost overrun in highway projects (Sohu , et al., 2017) .

In another research, in charge six main causes of cost overrun were identified out of forty causes in Ethiopia. Recognized significant causes were Increase in prices of materials, budget underestimation, late supplying of raw materials, insufficient check through the contract documents, and nonexistence of coordination at the design stage (Belachew, Mengesha, & Mohammed, 2017).

In Afghanistan, another research for identification of cost overrun factors were performed by Niazi and Painting. They indicated that:

1. Corruption;
2. Slow payment procedures by client;
3. Financial difficulties of contractor;
4. Security issues;
5. Change order by client;
6. Inflation

are the main causes of cost overrun in Afghanistan (Niazi & Painting, 2017).

Significance of cost overrun causes were investigated in another study on Gas-Oil construction projects in Iran by Derakhshanalavijeh and Teixeira. Causes of cost overrun were identified and evaluated and ranked based on their relative importance. They listed the main causes as:

1. Mistaken or incorrect cost appraisals;
2. Poor planning by consultant;
3. Frequent changes in designs;
4. Problem in skilled labor availability;
5. Fluctuation and changes in costs of equipment, labor, materials and transportation.

They stated that due to reason that the first three causes are direct responsibilities of consulate, there should be no delay in hiring a consultant. Otherwise cost overrun will inevitably occur (Derakhshanalavijeh & Teixeira, 2017).

In one of the most recent investigations, Akhund et al. performed a specific investigation on causes of cost overrun in construction industry of Pakistan. They aimed to discover the main causes of cost overrun in the period of pre-construction

planning phase. According to the statistical analysis results of their investigation, incorrect or inappropriate design, inaccurate estimates, differences or changes in scope of the work, resource management problems and change of orders are the most significant causes of cost overrun (Akhund, Khoso, Khan, Imad, & Memon, 2019).

Another latest investigation was aimed to identify the causes that resulting cost overrun in construction projects by Mavengwa et al. in Zimbabwe. By conducting a questionnaire, results were analyzed and ranked by the mean of ANOVA test:

1) Financial problems of owner;
2) Currency changes;
3) Poor contract management by consultant;
4) Variation of material prices;
5) Laws and regulations;
6) Problematic feasibility and project analysis by consultant;
7) Delay or slow decision making by client;
8) Foreign labor permits;
9) Political interfering to the project;
10) Delay in confirming design documents by client

was reported as the main and important ten causes of cost overrun (Mavengwa, Sukamani, & Nyoni, 2019).

2.5 Causes of Time Overrun

In the past three decades, considerable attention has been paid to study on identifying, nature and dependency of responsible causes that adversely influence success of Civil Engineering projects. In line with it, time criteria of construction projects are one of the common and important part of these investigations. These efforts illustrate and

verifies the importance of attention to identify adverse time causes which leads the construction projects into delay or time overrun.

Baldwin was one of the first researchers who conducted a nationwide study in United States by make an effort to identify causes of delays in construction industry. In this research seventeen causes were considered and inspected. Thereafter the most important causes were selected and with the aim to reduce costly consequences of delay, some methods were recommended (Baldwin & Manthei, 1971).

In another study that was done by Arditi et al. by means of conducting a survey through public agencies and contractors in Turkey. They identified responsible causes of delay and ranked them by their significance. Based on obtained results, shortage of some resources, financial difficulties of contractor, delay in design phase, administrative deficiencies, continual change orders and sizable additional works are the most significant reasons for delay in construction projects (Arditi, Akan, & Gurdamar, 1985).

Chan and Kumaraswamy evaluated the relative importance of delay important factors among 83 causes in construction projects at Hong Kong. Causes of delay were categorized into 8 different categories. Causes were analyzed and ranked based on role of involved parties and type of projects. As a result of the conducted research, 5 main and common causes of time overrun were identified and published (Chan & Kumaraswamy, 1997).

Al-Momani carried out an investigation to determine causes of time overrun on 130 public projects including schools, administrative buildings, residential buildings and

communication facilities in Jordan. According to obtained results, design changes, weather condition, economic condition, additional works or increase in quantity of work and late delivery of materials and equipment were main responsible causes of time overrun (Al-Momani, 2000).

Causes affecting time in Nigerian construction projects were investigated by Elinwa and Joshua. Twenty-three factors responsible for time overrun were identified and analyzed. As a result, it has shown that delay occurs in between 80 and 90 percent of construction projects. Moreover it was resulted that delay is more common in government or public sector construction projects (Elinwa & Joshua, 2001).

In a study by Long et al. sixty-two causes responsible for time overrun in Vietnamese construction projects were investigated. Probable occurrence rate and degree of impact on time of projects by each of causes were asked through conduction of a questionnaire. According to the result of investigation, inaccuracy of time prediction, slow project site clearness, slow issuing of permits by government, incompetent client representatives and use of outdated technologies had more impact on time of construction projects (Long, Ogunlana, Quang, & Lam, 2004).

In another established research that was conducted by Assaf and Al-hejji, investigators discovered that 70% of their studied projects were victim of time overrun. They also identified and observed 73 responsible causes of delay in construction projects and ranked them based on frequency of occurrence and severity. They also declared “change order” as the most common time overrun cause according to the responses of contractors, consultants and clients as respondents to the questionnaire (Assaf & Al-Hejji, 2006).

Causative factors responsible for time overrun in construction projects of Nigeria were assessed through concentrating on activity or inactivity of project parties and also external causes by Aibinu and Odeyinka. A questionnaire survey and quantifiable statistics and information form completed buildings were used in this study. Authors of this research were also identify, analyze and rank the 44 adverse causes contributed in time overrun (Aibinu & Odeyinka, 2006).

In a study in United Arab Emirates, most important causes of delay were investigated by conduction of a questionnaire and results were analyzed and ranked by RII method. According to obtained results, authors of the article claimed that more than fifty percent of projects in UAE experiences time overrun. They also revealed that the most important causes responsible for delay are approval of drawings by authority, insufficient early planning and slowness of the owners' decision making process (Faridi & El-Sayegh, 2006).

In their research, Sambasivan and Soon, identified the ten most critical causes affecting time of construction projects in Malaysia as followings:

1. Unsuitable planning by contractor;
2. Poor site management by contractor;
3. Inadequate experience of contractor;
4. Poor finance and payments for finished works by owner,
5. Disputes with sub-contractors;
6. Scarcity of materials;
7. Supply of labor;
8. Equipment accessibility and failure;
9. No communication between construction parties;

10. errors in the period of construction stage.

They also identified six effects of delay on construction projects (Sambasivan & Soon, 2007).

Sweis et al. carried out an investigation on causes of time overrun in residential building projects. Causes were identified, analyzed and categorized. According to the respondents of the questionnaire and interview with different construction parties, financial problems of the contractor and frequent change orders issued by client are the most important causes of construction delay in Jordan (Sweis G. , Sweis, Abu Hammad, & Shboul, 2008).

Abd El-Razek et al. aimed to investigate, identify the most significant causes of time overrun in construction building projects in Egypt. In their research all points of view belong to client, consultant and contractors were considered. After conduction of questionnaire survey and interviews, following results were obtained and defined as the most important causes responsible for delay:

1. Funding provision by contractor in construction period;
2. Delay in payments by client to contractor of project;
3. Design changes in the construction phase;
4. Employment of low skilled or not professional project managers or contract managers (Abd El-Razek, Bassioni, & Mobarak, 2008).

In another research in Thailand by Toor and Ogunlana, a questionnaire survey together with interviews were conducted in order to discover the most important problems causing time overrun in construction projects. Causes like lack of resources, poor

management by contractor, shortage of human resources and delays in design stage were observed and indicated as significant causes of delay (Toor & Ogunlana, 2008).

A similar study in Ghana by Fugar and Agyakwah-Baah indicated that from a list that consist of thirty-two adverse causes of time overrun, financial group of causes were ranked as first significant problem by respondents of conducted questionnaire. Following the first group of causes, materials group and scheduling and controlling group of causes were the most important causes of delay (Fugar & Agyakwah-Baah, 2010).

Mohammad and Issah carried out a study to identify, analyze and rank the adverse causes of delay in Nigeria's construction industry. As a result of the investigation, they reported that:

1) Improper planning,
2) Poor communication between construction parties;
3) Error in designs;
4) Shortage of materials

are the most important causes of time overrun in Nigeria (Mohammed & Isah, 2012).

Causes of time overrun and their effects on Iranian construction projects were investigated by Pourrostam and Ismail. They identified and ranked ten significant causes from a list of twenty-eight causes of time overrun obtained from literature review by conduction of questionnaire and interview. They reported important causes of delay as:

1) Delay in payments by owner of project;
2) Change orders by owner of project in construction period;

3) Poor construction site management;
4) Slowness in decision making process by owner of project;
5) Monetary problems of contractors;
6) Slowness of owner in review and approve of designs;
7) Disputes with subcontractors;
8) Poor planning and scheduling by contractor of project;
9) Inaccurate design documents;
10) Poor weather condition

adverse effects of time overrun on construction projects were also discussed on this research (Pourrostam & Ismail, 2012).

In another research, forty-five causes responsible for time overrun in construction projects of India were identified and assessed by factor analysis. Accordingly, following causes were identified as the most critical causes of construction time overrun (Doloi, Sawhney, Iyer, & Rentala, 2012):

1) Commitment deficiency;
2) Poor construction site management;
3) Inefficient construction site coordination;
4) Poor planning;
5) Poor clarity of project scope;
6) Poor communication between construction parties;
7) Poor and ineffective contract;
8) Below normal standard contract.

The other existing study in literature was conducted by Aziz in Egypt. Research has been done through a structured questionnaire for the respondents from public and

private construction companies and brain storming. In this manner 99 causes of delay were identified and categorized into 9 categories. By the mean of relative importance index analysis, causes were sorted and ranked (Aziz R. F., 2013).

In Turkey, Gunduz et al. performed an investigation to quantify responsible delay causes in construction projects. They identified, categorized and analyzed eighty-three causes of delay based on results of interviews with professionals and literature review. They ranked and listed the causes based on RII method. Inadequate experience of contractor, poor project planning and scheduling by contractor, ineffective construction site management and supervision and Design changes by client or his representatives in construction phase and late delivery of materials to the construction site were recognized and indicated as the most important causes of time overrun in Turkey (Gunduz, Nielsen, & Ozdemir, 2013).

In an investigation performed by Hwang et al. significant causes affecting time of public projects in Singapore was identified and recommendations to respond to adverse causes were suggested. Results of the study indicates that construction site management, coordination in between construction project parties, design changes by owner in construction phase, accessibility of laborers on construction site, accessibility of material in construction site, and accessibility of staff to manage construction projects are the most important and critical causes of time overrun of public housing projects in Singapore (Hwang, Zhao, & Ng, 2013).

Next available investigation in literature was done in Turkey where investigators aimed to identify the most critical causes responsible for time overrun. Based on a literature review and structured questionnaire, researchers indicated that suspension of

the project by client, postponement of payments by client to the contractor and unrealistic authorized project period respectively (Cülfik, Sarıkaya, & Altun, 2014).

Seventy-three adverse causes of time overrun was investigated in case of frequency, severity of impact and importance of each cause in Iran by Sepasgozar et al. The most important causes of delay was identified and indicated as contractor organization issues, shortage of labor, external cause, lack or shortage of material, design issues like design changes, owner issues, restrictions in new technologies and consultant related causes respectively (Sepasgozar, Razkenari, & Barati, 2015).

One more investigation on causes of time overrun was done by Aziz and Abdel-Hakam in Egypt. Two hundred ninety-three causes of delay in construction projects were listed and categorized into contractor, consultant and site design engineers. By applying RII analysis the most important causes in each category was identified and listed. More over the most twenty significant causes were listed in which owner financial problems ranked as first (Aziz & Abdel-Hakam, 2016).

Another research was performed in Cambodia by Durdyev et al. to identify various time overrun causes in residential building projects. By the means of questionnaire and structured interview with contractors and consultant the major cause were identified. Results were analyzed with RII method, and the causes were ranked and listed accordingly as followings:

1) Scarcity of materials on construction site;
2) Impractical project scheduling;
3) Delay in delivery of material to construction site;
4) Shortage of trained labor in the site;

5) Complexity of project;
6) Nonappearance of labor;
7) Delay in payments for the completed activities by owner to contractor;
8) Poor construction site management;
9) Delay by subcontractor of project;
10) Accidents as a reason of poor safety measures in construction sites (Durdyev, Omarov, & Ismail, 2017).

In one of the most recent researches performed by Oyegoke and Al Kiyumi, adverse causes of time overrun in megaprojects and their effects on time of projects in Sultanate of Oman was studied. As a result of literature review and outcomes of questionnaire survey and analyzing the results, they indicated that following causes are the most significant causes of time overrun in Oman:

1) Preference of lowest bid over proper bid for the owner;
2) Monetary condition of contractor;
3) Slowness of owner in decision-making;
4) Poor planning and scheduling by contractor of project.

They also pointed out that over budgeting or additional need for money and time overrun are the most important and natural consequences for above mentioned causes (Oyegoke & Al Kiyumi, 2017).

Rezaei and Jalal in part of their investigation, studied the adverse causes of cost overrun in Northern Iraq. A questionnaire survey according to forty-two causes of cost overrun obtained in the literature taken into consideration. They concluded that, inadequate labor and skill accessibility, unsuitable policies of contractor, and

domination of construction industry by foreign firm and aids are three main causes of cost overrun in the region (Rezaei & Jalal, 2018).

In one of the most recent studies, Soomro et al. aimed to investigate and identify the key causes of delay in the construction of building projects in Pakistan. To reach the objectives of this research, researchers conducted a questionnaire by asking about fifty-one causes of time overrun. According to the results, they indicated that Monetary problems of contractor; poor experience level of contractor, weather conditions, delay in delivery of the materials to the site area, design errors and shortage of experienced labor are the most significant and important causes that highly impacting and lead the projects into time overrun (Soomro, Memon, Chandio, Sohu, & Soomro, 2019).

There are many other publications available in literature that addresses the cost and time overrun problem. A list including the title of articles, publishing date and author's name are gathered and tabulated in Appendix1.

2.6 Concept of Project Management

Young defined the term of project manager as an individual who is responsible for project every day and his duty is to complete the project on agreed time, cost and quality (Young, 2006).

Lock specified that the primary aim of the project manager is to satisfy the client in observing promised timeframe and authorized cost without any additional money expenditure (Lock, 2007).

Controlling time and cost is an uninterrupted and steady duty of project manager. "Whatever the project manager's specific duties in relation to the various stages of a

project, there is the continuous duty of exercising control of project time, cost and performance" (The Chartered Institute of Building, 2014).

A successful project management was defined by Olsen as attainment to delivery within the budget, time and quality constraints (Olsen, 1971). Munns and Bjeirmi revealed that project management plays a role in project success. They also defined a successful project management as "completion to budget, satisfying the project schedule, adequate quality standards, and meeting the project goal" (Munns & Bjeirmi, 1996). Stojcetovic et al. have arrived at the conclusion that triple constraint of cost, time and quality are the most preferred measure to assess the project success among project managers (Stojcetovic, Lazarevic, Prlincevic, Stajcic, & Miletic, 2014).

Therefore, it can be concluded that a project manager plays a starring role in successful accomplishment of project goals and objectives by delivering it to the final closedown on authorized time, targeted cost and specified quality.

2.7 Preventive and Corrective Actions & Time and Cost Overrun

Project managers or project management teams are required to complete the project in a timely and cost effective manner. According to the outcomes of aforementioned studies in previous sections, it is observed that most of investigations claimed that their identified adverse causes, proposes a foundation for policy makers, planners, project managers and project management teams. However most of those investigation stopped on that point (Lo, Fung, & Tung, 2006), (Aibinu & Odeyinka, 2006), (Iyer & Jha, 2005), (Shehu, Endut, & Akintoye, 2014) , (Roslan, Zainun, & Memon, 2014).

These type of researches become more valuable when it comes to well cognition of the causes and their main roots of occurrence together with instruction, recommendations

and suggestion to practitioners to prevent occurrence or mitigate and reduce consequences of adverse causes. In line with that and apart previously mentioned investigations, there are only several researches that have been progressed extensively onto finding and offering solutions to prevent and alleviate effects of identified adverse causes on time and budget of projects.

Wang et al. identified risk factors and offered mitigation measures in a risk management framework to different construction practitioners (Wang, Dulaimi, & Aguria, 2004).

Abdul-Rahman et al. investigated the types of delay, identified causes that are responsible for delay in construction and suggested recommendations on how to prevent or alleviate the causes leading to delay problem (Abdul-Rahman, et al., 2006).

In a study by Olawale and Sun, ninety mitigation measures for only five highest ranked common causes in time and cost criteria developed and recommended (Olawale & Sun, 2010).

Memon et al. in another research studied time and cost management performance in construction projects and 13 mitigation measures were also offered to improve the time control performance (Memon, Rahman, & Abdul Azis, 2012).

In another study by Azis et al., fifteen mitigation strategies to control cost overrun factors were proposed for construction projects in Malaysia (Azis, Memon, AbdulRahman, & Abd.karim, 2013).

Khademi analyzed time overrun causes and suggested mitigation procedures to reduce effects of them (Khademi, 2014).

Roslan et al. carried out an investigation by conduction of an extensive literature review among published articles and summarized identified measures in a table for time and cost overrun causes during implementation phase of construction projects (Roslan, Zainun, & Memon, 2014).

Another study were performed in India by Mulla and Waghmare suggested remedial measures as clues to deal with time and cost overrun by modifying strategies (Mulla & Waghmare, 2015).

2.8 Measurement of Project Performance

Project performance measurement usually indicates the measure of project success or failure. Project performance measurement can be quantitative or qualitative. Performance measurement is the procedure of computing the efficiency and effectiveness of past activities, and a performance measure is a parameter used to quantify the efficiency and or success of past activities (Neely, Adams, & Kennerley, 2002). Takim et al. stated that performance measurement is utilized as a systematic method of judging project performance by assessing the inputs, outputs and project outcomes at closing date. They also indicated that when measurements are being performed, contractors, consultants and the management team's performances are held responsible as the main causes for the failure of a particular project (Takim, Akintoye, & Kelly, 2003).

Cha and Kim explained that the performance of a specific construction project can be assessed by how many of the project objectives are attained in terms of cost, time, quality, health and safety, environment, and onwards (Cha & Kim, 2011).

Project performance measurement is a relative issue. For instance, time and cost of a project as a performance indicator is compared with authorized cost and specified duration in contract. Generally, project managers put large amount of efforts to be within the cost and time limitations. However, there are adverse conditions and causes which lessen the performance of project managers controlling cost and time.

Generally, Project performance measurements is expressed in terms of a relative score. This score can be computed relatively simply according to the statistical data of the construction projects. This statistical data might be amount of time overrun, magnitude of cost overrun, causes responsible for delay and some other criteria.

Ahbeb et al. believed that there is a vital need for greater and better attention on pulling out the causes that critically lessen the efficiency of project managers. To attain this objective and obtain reliable results, mathematical tools and methods can be applied to compute relative management efficiency or make a comparison between project management efficiencies (Ahbab & Celik, 2019).

One of the performance analyzing and measuring tools is Data Envelopment Analysis (DEA). It is a nonparametric recent mathematical tool for measuring relative managerial performance and determining efficiency of project managers.

Only a few researches have been reported by investigators in construction industry area of knowledge that employ DEA to score performance of projects.

Performance of construction contractors were measured by means of DEA by Hasan et al. in 2008. They aimed to develop a performance benchmarking system for construction companies. They accomplish their study by detecting overall efficiency by benchmarking economical, methodological, environmentally, and social performance. Study were implemented on thirty seven construction projects in Syria and according to the results about eighty percent of the studied projects were inefficient (Hasan, Omran, & Maya, 2008).

El-Mashaleh et al. aimed to measure and benchmark safety performance of construction contractors. On this research DEA was employed to assess safety performance or efficiency of forty-five contractors in relative to each other in Jordan. They indicated that spending more resources in compare with other contractors does not necessarily an outcome with better safety performance (El-Mashaleh, Rababeh, & Hyari, 2010).

Construction Project success was investigated by Zahedi- Seresht et al. in Iran. In this investigation, it is aimed to rank the construction success factors. Investigators studied nine projects and projects were ranked after performing of an analysis by DEA. Studied criteria were determined according to the results of questionnaire. Time and cost performance, quality of project, health and safety at work and consumer satisfaction were five studied success criteria (Zahedi- Seresht, Akbarijokar, Khosravi, & Afshari, 2014).

In another research DEA tool was used to perform Safety-based performance analysis of construction sites in Canada. Number of incidents and safety climate causes used as output and input of investigation and a sensitivity analysis were conducted. Their results showed that the number of incidents incurred at construction sites, is the leading reason correlating with the efficiency of construction sites. Based on the results of sensitivity analysis they also concluded that the "work pressure" is the most impacting safety climate factor (Nahangi, Chen, & McCabe, 2019).

2.9 Lessons Learned and Knowledge Management

All information data in the above mentioned investigations obtained through primary and/or secondary data. One of the most effective ways to reduce the time and cost of construction projects and increase the productivity, is technical documentation of projects. Technical documentation, is one of the knowledge management tools for transferring past and current experiences of tacit and explicit knowledges. Some of the organizations and construction parties publishes their tacit and explicit knowledge and experiences in online or offline platforms.

Alhaji et al. claimed that knowledge has not been shared properly by construction practitioners and due to this reason the time, cost and quality performance of construction organizational affected (Alhaji, Amiruddin, & Abdullah, 2013).

It is known that using past gained experiences in managing time and cost of construction projects is crucial. Therefore, Kirvak et al. aimed to find how the tacit and explicit knowledge are taken, kept, shared and used in upcoming projects and also they investigate the barriers for knowledge management. Thereafter a web-based system as knowledge management platform for contractors were developed by them in order to

use by contractors in order to practice both types of knowledge effectively (Kivrak, Arslan, Dikmen, & Birgonul, 2008).

In another research, Kasimu et al. intended to define way out to the cost problems of construction projects in Nigeria by the means of knowledge management (KM) (Kasimu , Amiruddin, & Abdullah, 2013).

It is obvious that, in construction sites different types of experiments is made every now and then due to nature of civil engineering projects. Tacit experiences and method of solving the problems by project managers, engineers and workers should be captured and recorded for future uses. Need the solutions and past experiences in solving the problems will help the construction managers to save time and money. Therefore, referring to recorded databases might be useful and beneficiary for construction practitioners. Better time and cost management efficiency, lack of re-experiencing mistakes are two important advantages of applying and usage of KM procedures.

2.10 Summary and Lessons Learned from Literature Review

Based on the comprehensive literature, it can be summarized that, most of the abovementioned researches were performed in developing countries. Due to plenty of articles presented in the field of identification of time and cost overrun, it can be stated that, this topic still is a significant phenomenon in developing countries.

In addition, increasing the number of research focusing on the country of study, type of construction and the culture of people involved in construction projects is an underlying need. Moreover, there is a shortage of study into how to deal with delays

and cost overrun causes country wise in the literature in compare with number of investigations which only identified the adverse causes.

It is believed that, culture of people, construction laws and regulations, technological developments, availability of material and equipment, quality of feasibility studies and project management are the main root causes responsible for time and cost overrun in developing countries. Therefore, to overcome time and cost overrun in large projects in developing countries, it is vital to:

1) Improve project management methods;
2) Get to know the culture of the people at the project site specially in international projects;
3) Paying more attention to feasibility and appraisal studies.

Chapter 3

METHODOLOGY

3.1 Introduction

This chapter defines the performed methodology to meet the aims and objectives of current dissertation. It explains, data gathering and procedures and methods used for data analysis. The study consists of comprehensive literature review and case studies, data analysis, computation of time and cost efficiency of construction projects, preventive and mitigation measures for critical causes that influence time and cost efficiency of project managers and a website which developed as a knowledge management tool to disseminate methods to oppose adverse causes of time and cost overrun for the use of construction practitioners and project managers.

3.2 Research Data Collection

As a primary step in current study, a literature review was performed to investigate the actuality of time and cost overrun as a problem in construction industry. Thereafter an investigation was carried out to identify the adverse causes responsible for both time and cost overrun in large construction projects. For this purpose, out of about hundred projects only sixty three project completion reports (PCR) for large construction projects published by Asian Development Bank (ADB) were selected and used as secondary data as indicated in Table 1. The number of projects was reduced due to reason that designated projects are a victim of only time overrun or cost overrun, or time and cost overrun at the same time. Moreover, selected projects are large in term of total estimated cost in their appraisal documents.

Secondary Data is referred to the collected data and records that have been documented and regularly published by International organizations and government sections. The World Bank, ADB, AFDB and the US Department of Transportation are some of the organizations that frequently publish their project data. Study on secondary data is advantageous. Reduced time and expense of obtaining the data, the higher quality of the data, and the enhanced objectivity, accuracy, validity, and reliability of the data are a good reason to get benefited from secondary data (Vartanian, 2011).

Table 1: Geographical location and completion date of selected ADB projects

#	Title of Project	Completion Date	Country
1	Chittagong port project	1982	Bangladesh
2	Ports development projects	1991	New Guinea
3	Rural access roads project	2003	Pakistan
4	Third road improvement project	2003	Laos
5	Jamuna Bridge project	2000	Bangladesh
6	Road overlay and improvement project	2002	Bangladesh
7	Third road improvement project	2003	Nepal
8	Transport infrastructure development project	2002	Guinea
9	National highways project	2008	India
10	Transport infrastructure project	2001	Tonga
11	Rural infrastructure development project	2006	Nepal
12	Bangkok urban transport project	2002	Thailand
13	Second road improvement project	2003	Vietnam
14	Airports improvement project	2001	Laos
15	Jing-Jiu railway technical enhancement project	2000	China
16	Southern transport development project	2011	Sri Lanka
17	Shenmu - Yanan railway project	2006	China
18	Xieng khouang road improvement project	2006	Laos
19	Daxian - Wanxian railway project	2006	China
20	Third road upgrading (sector) project	2015	Fiji
21	Road network improvement project	2009	Sri Lanka
22	Primary roads restoration project	2006	Cambodia
23	Chongqing - Guizhou roads development project (Leichong expressway	2008	China
24	Southern Yunnan road development project	2006	China
25	Greater Mekong sub region: Cambodia road improvement project	2011	Cambodia
26	Rural access roads project	2008	Laos
27	Roads for Rural Development Project	2014	Laos

28	Shaanxi roads development project	2010	China
29	Road sector development project	2009	Sri Lanka
30	Western transport corridor project	2014	India
31	Road sector development program	2010	Pakistan
32	West Bengal corridor development project	2012	India
33	Western Yunnan roads development project	2011	China
34	Road network project	2013	Bhutan
35	Road rehabilitation project	2008	Tajikistan
36	Guangxi roads development project	2008	China
37	Xi'an urban transport project	2011	China
38	Ningxia roads development project	2013	China
39	Gansu roads development project	2013	China
40	Central Sichuan roads development project	2014	China
41	National highway corridor (sector) i project	2015	India
42	Chongqing - Guizhou roads development project (Chongzun expressway)	2008	China
43	Dushanbe–Kyrgyz border road rehabilitation project	2010	Tajikistan
44	Guangxi roads development ii project	2011	China
45	Hunan roads development ii project	2012	China
46	Regional road development project	2015	Mongolia
47	East–west highway improvement project	2011	Azerbaijan
48	Chhattisgarh state roads development sector project	2014	India
49	North-West Frontier Province Road Development Sector and Sub regional Connectivity Project	2012	Pakistan
50	Southern transport corridor road rehabilitation project	2011	Kyrgyz
51	Central Yunnan roads development project	2015	China
52	Andkhoy – Qaisar road project	2010	Afghanistan
53	Madhya Pradesh state roads sector project ii	2015	India
54	Eastern Sichuan roads development project	2014	China
55	Hunan roads development iii project	2014	China
56	Dushanbe–Kyrgyz border road rehabilitation project, phase ii	2013	Tajikistan
57	Heilongjiang road network development project	2012	China
58	Western Guangxi roads development project	2014	China
59	Afghanistan: north–south corridor project	2013	Afghanistan
60	Xinjiang regional road improvement project (Korla – Kuqa section)	2014	China
61	Carec transport corridor 1 (Bishkek–Torugart road) project	2013	Kyrgyz
62	Carec regional road corridor improvement project	2014	Kyrgyz
63	Second road rehabilitation and improvement project	2014	Nepal

Each PCR contains the project description, assessment of the bank in design and implementation of the project, performance, and overall evaluation and recommendations at the end. In depth information about outputs of the project covering scope and objectives, targeted and actual cost in addition to schedule, detected adverse causes in time and cost aspects, and implementation arrangements are also provided.

The existence of numerous articles with the subject of delay and cost overrun in construction projects and the continued publication of similar articles in scientific journals is an undoubtable reason for the persistence of this problem. For more information, refer to appendix1. Aforementioned articles demonstrate that despite many technological advances and training of project managers' construction projects are still suffering failure in cost and time control.

After confirming the existence of the problem based on an extensive literature review, an investigation on selected large construction projects was done. The aim of the investigation was to identify adverse causes of time and cost overrun. For this purpose, each of the PCRs was studied with an excessive care to find reported adverse time and cost causes that led those projects to overruns. It is also aimed to derive the consequences of the extracted causes on the selected projects.

Afterward a summary of sixty-six identified adverse causes derived from sixty-three case studies and literature review were listed and tabulated. Subsequently extent of cost and time deviation from targeted duration and budget in contract were carefully calculated and obtained.

Table 2: Identified causes of cost and time overrun

Code	Adverse Causes
1	Inadequate front-end planning of project
2	Inaccurate initial project scope
3	Inadequate communication between design and construction parties
4	Poor site management
5	Not communicating with all parties dealing with the budget
6	Owner interference in the project
7	Poor project management, construction management, and supervision
8	Poor contract management (inexperience of following contract condition)
9	Poor provision of information to project participants
10	Inflation
11	Failure to resolve change orders and prevent them from becoming claims/disputes
12	Too many construction activities going on at the same time
13	No financial incentive to contractor to finish the project ahead of schedule
14	Slowness of the owner's decision-making process (approval of activities)
15	Slow financial and payment procedures adopted by the client
16	Contract modifications and variations (replacement, addition, and change)
17	Delay in approval of feasibility study, drawings, and material
18	Financial difficulties of owner/client
19	Long period between time of bidding and contract award (initial delay)
20	Increase in quantity of work (additional works)
21	Design changes
22	Absence of consultant's staff on the project site
23	Lack of technical and managerial skills of consultant's staff (poor performance)
24	Lack of quality assurance, control
25	Poor documentation - incomplete drawings, poor drawings, design deficiencies
26	Slow inspection of completed works
27	Equipment and manpower shortage and bad distribution on site
28	Poor communication with consultant and owner
29	Financial difficulties of contractor
30	Low productivity of labor
31	Inadequate contractor experience (poor performance of contractor)
32	Rework and wastage of materials
33	Delay in mobilization by contractor
34	Inadequate and incompetent subcontractors
35	Slow or delayed material or equipment delivery to project site
36	Unavailability or shortage of required materials in the local market on time
37	Fluctuation and escalation in prices (materials, machinery, labor, equipment)
38	Monopoly of construction materials supply (steel, cement)
39	Equipment availability and failure
40	Lack of maintenance for the equipment

41	Skilled labor shortage
42	Poor and unforeseen site conditions (location, ground, geological, events, security)
43	Severe weather problems (heat, cold, snow, rain, cyclone)
44	Political issues, changes
45	Poor health and safety conditions on site
46	Changes in laws and regulations during the project, obstacles from government
47	Change in exchange rate
48	Inadequate design team experience
49	Extension of the construction phase (delay)
50	Complicated administrative and governmental procedures (institutional problems)
51	Damage of structure and equipment breakdown (flood, cyclone)
52	Increase or change in scope of the project
53	Underestimate and inaccurate appraisal (missing measures, cost adjustment)
54	Extension of consultant contract
55	Court cases (litigation)
56	Unexpected issues (public obstruction, earthquake, flood, security issues)
57	Quitting the work by contractor
58	Poor procurement procedure (longer period or procedures in bidding)
59	Change in quality of the work
60	Inaccurate estimation for duration of the project
61	Additional project management, consultancy, and administration costs
62	Increase in the amount of land acquisition, price, and compensation
63	Delay in land acquisition
64	Delay in appointment of consultant
65	Low contract bid
66	Repetition of tendering or bidding procedure

In the next step, and as it was mentioned before, carefully driven causes of time and cost overrun for each of projects were listed. Thereafter, causes of time and cost overrun were counted and ranked by the number of repetitions separately to identify the most frequent causes.

Table 3: Ranking of the first twenty critical causes influencing time of the projects

Code	Causes of delay	Frequency	Rank
19	Long period between time of bidding and contract award	16	1
33	Delay in mobilization by contractor	13	2
43	Severe weather problems (Heat, Cold, Snow, Rain, Cyclone)	12	3
58	Poor procurement procedure	11	4
21	Design changes	10	5
31	Poor performance of contractor	10	5
14	Slowness of the owner's decision-making process	10	5
20	Increase in quantity of work (Additional works)	9	6
7	Poor project management, construction management and supervision	8	7
52	Increase or change in scope of the Project	8	7
63	Delay in Land Acquisition	8	7
35	Slow or Delayed material or equipment delivery to project site	7	8
2	Inaccurate initial project scope	7	8
64	Delay in appointment of consultant	7	8
17	Delay in Approval of feasibility study, drawings and material	6	9
50	Complicated administrative and governmental procedures (institutional problems)	6	9
18	Financial difficulties of owner/Client	5	10
44	Political issues-Changes	5	10
42	Poor and unforeseen site conditions (Location, ground, geological, events, security, ETC)	5	10
36	Unavailability or shortage of required materials in the local market on time	5	10

Table 3 shows the first twenty adverse causes of time overrun. According to the tabulated table, "Long period between time of bidding and contract award", ranked as the first frequent cause that influence time of large construction projects. In the other word aforementioned cause is the more frequent cause and repeated 16 times in out of 63 studied projects.

With the same method, the most frequent causes of cost overrun were counted and ranked separately in Table 4. As it is shown in the table "Fluctuation and escalation in

price of materials and equipment" is the most frequent cause of cost overrun in considered projects.

Table 4: Ranking of the first ten critical causes influencing cost of the projects

Code	Causes of cost overrun	Frequency	Rank
37	Fluctuation and escalation in prices	21	1
47	Change in exchange rate	13	2
53	Underestimated and inaccurate appraisal	12	3
52	Increase or change in scope of the project	11	4
62	Increase in the amount of land acquisition, price, and Compensation	11	4
21	Design changes	10	5
2	Inaccurate initial project scope	7	6
20	Increase in quantity of work (Additional works)	7	6
42	Poor and unforeseen site conditions (Location, ground, geological, events, security)	7	6
61	Additional project management, consultancy and administration costs	6	7

Subsequently, a set of data were developed and modelled using the performance improvement management software (PIM-DEA) (Emrouznejad, Ali; Thanassoulis, Emmanuel;, 2017).

In order to make an analysis on time aspect, 20 most frequent causes of time overruns were input related to 51 projects. In the same manner a total of 38 projects with 10 most frequent causes were also modelled for cost aspect. This combination of dataset was considered due to the reason that the number of selected projects has to be greater than the maximum number between (m × s) and [3 × (m+ s)]. In this formula m stands for the number of input and s represents the number of output criteria (Cooper, Seiford, & Tone, 2006). Figure 1 and Figure 2 shows a sample part of data entry tables for time and cost overrun causes and DMUs.

	B	D	E	F	J	L	QQ	T/R%	1/T/R
	Index1	Index2	Index3	Index4	Index5	Index6	Index20		1/0.92
DMU01	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	92	1.08333
DMU02	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	41	2.44444
DMU03	0.00001	0.00001	0.00001	1	1	1	0.00001	48	2.07692
DMU04	0.00001	0.00001	1	0.00001	0.00001	0.00001	0.00001	49	2.04634
DMU06	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	36	2.75
DMU07	0.00001	0.00001	0.00001	1	0.00001	0.00001	0.00001	7	13.4417
DMU08	0.00001	0.00001	0.00001	0.00001	1	0.00001	0.00001	69	1.44079
DMU09	1	0.00001	0.00001	1	0.00001	0.00001	0.00001	109	0.91781
DMU10	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	12	8.43478
DMU12	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	67	1.5
DMU13	0.00001	0.00001	0.00001	1	0.00001	0.00001	0.00001	20	4.87955
DMU14	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	1	26	3.88818
DMU15	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	299	0.33431
DMU16	0.00001	0.00001	0.00001	0.00001	0.00001	1	0.00001	117	0.85714
DMU18	0.00001	1	1	0.00001	0.00001	1	0.00001	80	1.25
DMU19	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	49	2.0411
DMU20	0.00001	0.00001	0.00001	0.00001	1	0.00001	0.00001	148	0.67564
DMU21	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	1	40	2.5
DMU22	0.00001	0.00001	1	0.00001	0.00001	0.00001	0.00001	65	1.53846
DMU23	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	40	2.47318

Figure 1: Input & Output Data - Projects versus causes of time overrun

The output of each model was taken as inverse of time and cost overrun percentages. By applying this method and through the PIM-DEA software, the effect of each of causes on project management performances was studied and critical ones were found separately for each of time and cost criteria. Measuring was done by applying the Charnes, Cooper, and Rhodes (CCR) model considering the causes affecting each of the time and cost criteria. Then, the relative managerial efficiency score was provided as an efficiency score by the PIM-DEA software.

	EEE	GGG	HHH	JJJ	NNN	TTT	XXX	YYY	GGGG	HHHH	C/R%	1/C/R
	Index1	Index2	Index3	Index4	Index5	Index6	Index7	Index8	Index9	Index10		
DMU01	0.00001	1	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	10.71	9.34131
DMU02	1	1	0.00001	0.00001	1	0.00001	0.00001	0.00001	0.00001	0.00001	29.20	3.42410
DMU04	0.00001	0.00001	0.00001	0.00001	0.00001	1	0.00001	0.00001	0.00001	0.00001	6.32	15.8333
DMU06	0.00001	1	1	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	2.49	40.1140
DMU10	0.00001	0.00001	0.00001	1	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	6.48	15.432
DMU14	0.00001	0.00001	1	0.00001	0.00001	1	1	0.00001	0.00001	0.00001	100.67	0.99334
DMU15	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	1	0.00001	0.00001	3.85	25.9512
DMU16	0.00001	1	0.00001	1	0.00001	0.00001	1	1	0.00001	0.00001	206.34	0.48462
DMU20	0.00001	1	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	87.56	1.14213
DMU21	0.00001	1	0.00001	1	0.00001	1	0.00001	0.00001	0.00001	0.00001	48.50	2.06187
DMU24	1	0.00001	0.00001	1	1	0.00001	1	1	0.00001	1	27.94	3.57946
DMU25	0.00001	0.00001	1	0.00001	0.00001	1	0.00001	0.00001	0.00001	0.00001	12.22	8.18373
DMU27	1	0.00001	0.00001	0.00001	0.00001	0.00001	1	0.00001	0.00001	0.00001	26.17	3.82066
DMU28	1	0.00001	0.00001	0.00001	1	0.00001	1	0.00001	0.00001	0.00001	27.54	3.63069
DMU29	0.00001	1	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	10.38	9.63541
DMU30	0.00001	1	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	21.80	4.58737
DMU32	0.00001	1	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	45.22	2.21153
DMU33	0.00001	0.00001	0.00001	1	1	1	1	0.00001	0.00001	0.00001	31.74	3.15105

Figure 2: Input & Output Data - Projects versus causes of cost overrun

Time and cost management efficiency can be well-defined as a bunch of management methods which reduces the overall consequence of adverse causes leading the projects to experience duration and budget overrun. In other words, managing construction activities by minimizing the influence of adverse causes and reach the best output, which is the accomplishment of the goals and objectives in the specified time and budget.

Managerial efficiency can be defined as a comparative measure. Project management teams have dissimilar efficiency in taking decisions and adjusting cost and time criteria in occurrence of affecting adverse causes. Ability of those teams in ordering the tasks by priority, taking suitable actions in front of causes and reducing defects of causes will express the degree of their success in efficient time and cost controlling.

With the aim of examining the significance of each of adverse causes on the time and cost management performance, sensitivity analysis tool was implemented. Under the light of the sensitivity analysis, the effect of each of the causes on overall time and cost management efficiency score was verified. This particular analysis allowed the identification of the degree of deviation or in better words, the extent of influence of each cause in terms of effect on the efficiency of project management of construction projects.

The consecutive steps followed in current research for identifying the greatness of impact of each cause on management efficiency were;

1) Exclusion of causes as input from the critical adverse causes list one by one,

2) Calculation of the efficiency score of project managers following to performing of step (1),
3) Computation of the rate of decrease in value from earlier obtained efficiency average with the intention of determining the level of importance for each cause.

In another important part of this study and based on the obtained results, critical causes of time and cost overrun obtained by sensitivity analysis tabulated in Table 12 were selected. Meanwhile other literature review and by personal interview was done to prepare a new dataset containing, preventing actions and mitigation measures to perform right and effective decision against adverse causes. In addition, the benefits of social networking web applications such as ResearchGate and LinkedIn were utilized to get comments of practitioners as well.

After summarizing and performing all above mentioned studies, a kit and a website was developed to give instructions and hints to project managers. The aim of developing such a website is to provide a platform for construction practitioners to assist them to learn and understand how to prepare themselves to react against adverse causes of time and cost overrun. Also it gives the ability to project managers to decide by which methodology they can prevent occurrence of each cause and by what way they can mitigate the consequences of the adverse causes after occurrence.

Chapter 4

LARGE CONSTRUCTION PROJECTS SUPPORTED BY ADB: A CASE STUDY

4.1 Introduction

Time and cost at completion date of construction projects are 2 important criteria to measure success of any project as additional to quality. Most of construction projects regularly experience delay and cost overrun. When it comes to large projects, the amount of delay and cost overrun becomes more important. Moreover, the destructive consequences of adverse causes will be much greater. Due to this reason, identification of time and cost overrun causes and the lessons learned by large construction projects may assist to better outcomes in upcoming projects.

In order to achieve to one of the objectives of this study, sixty-three large projects which supported by Asian Development Bank (ADB) were selected as case study. It should clarify that necessary data including objectives of project, schedule, cost data and reasons of cost and time overrun has been taken from published "Project Completion Report" (PCR) for each project by ADB.

In this chapter, sixty-three selected ADB projects are introduced.

4.2 Who is ADB

ADB is a regional development Bank with field offices across the world. This Bank is modeled like World Bank (WB). ADB assists its members and partners by providing loans, technical assistance, grants, and equity investments to promote social and economic development (Asian Development Bank, 2019).

4.3 Project Completion Report

Project completion report is an official document of finishing of a project. A project Completion Report can also define as an organized reporting document of project prepared by the project manager.

Completion reports consists of the project's expected influence, outcome and outputs; conduction of activities; evaluation and attainment of the anticipated outcomes; an assessment and rating; major lessons; and recommendations and follow-up actions (Asian Development Bank, 2019).

4.4 Studied Large Construction Projects

Selected sixty-three large construction projects, supported by ADB, are introduced. Selected projects are Civil Engineering Transportation projects. All selected projects were victims of only time or only cost overrun or both of time and cost overrun in the same time. For instance, project 5 is a victim of cost overrun without any delay while project 7 is only a victim of time overrun and project 2 is a victim of both time and cost overrun. Those project summaries are given below.

4.4.1 Chittagong Port Project

This project was constructed in Bangladesh. Based on ADB’s PCR (Asian Development Bank, 1982):

4.4.1.1 Objectives

The project aimed to reach following objectives:

1. To provide the rehabilitation, upgrading and improvement of the facilities at Chittagong;
2. To procure equipment for reducing the turn-around time of ships.

4.4.1.2 Cost and Time Data

The total project budget was predicted at appraisal to be $15.60 million while project was done with final total cost of $11.47million. For time aspect, according to project implementation schedule section in PCR document 92% of time overrun was occurred and experienced in this project.

4.4.2 Ports Development Project

This project was constructed in New Guinea. Based on ADB's published PCR document (Asian Development Bank, 1991):

4.4.2.1 Objectives

The project aimed to reach following objectives:

1) To facilitate managing of an increasing capacity of port-related domestic and overseas traffic efficiently;
2) To encourage the all over economic and social development of the agriculturally rich coastal hinterlands and improvement of the international competitiveness of main export;
3) To assist in the institutional reinforcement of the Papua New Guinea Harbors Board.

4.4.2.2 Cost and Time Data

The total project budget was predicted at appraisal to be $15.34 million while project was done with final total cost of $17.27 million. For time aspect, according to project

implementation schedule section in PCR document 41% of time overrun was occurred and experienced in this project.

4.4.3 The Rural Access Roads Project

This project was constructed in Pakistan. Based on ADB's published PCR document (Asian Development Bank, 2003):

4.4.3.1 Objectives

The project aimed to reach following objectives:

1) To assist the Government of Pakistan to improve farm-to-market roads in Sindh, Punjab, North West Frontier Province, and Baluchistan;
2) To support agricultural and rural development, with the aim of job creation in rural small-size industries and businesses for poverty reduction;
3) To reduce costs of transportation to ease move of goods and passengers more efficiently;
4) To enhance community mobility in rural level with the aim of providing a better accessibility to education, health, and social services and reinforcement of domestic skills to design and construct the network of country's rural access road.

4.4.3.2 Cost and Time Data

The total project budget was predicted at appraisal to be $178 million while project was done with final total cost of $156.52million. For time aspect, according to project implementation schedule section in PCR document 48% of time overrun was occurred and experienced in this project.

4.4.4 Third Road Improvement Project

This project was constructed in Lao. Based on ADB's published PCR document (Asian Development Bank, 2003):

4.4.4.1 Objectives

The project aimed to reach following objectives:

1) To decrease costs of transportation to ease move of goods and passengers more efficiently in project-related-area;
2) To support rural development through the community mobility in rural level;
3) To strengthen domestic skills to design, construct and, maintain the network of country's rural access road and supporting the Government-related- road maintenance program.

4.4.4.2 Cost and Time Data

The total project budget was predicted at appraisal to be $23.75 million while project was done with final total cost of $25.25 million. For time aspect, according to project implementation schedule section in PCR document 49% of time overrun was occurred and experienced in this project.

4.4.5 Jamuna Bridge Project

This project was constructed in Bangladesh. Based on ADB's published PCR document (Asian Development Bank, 2000):

4.4.5.1 Objectives

The project aimed to reach following objectives:

1) To connect separated parts of east and west in country due to existence of Jamuna River;
2) To help stimulate economic growth through easing movements of passengers and freight;

3) To provide a railroad network between the west and the east in a cost effective way.

4.4.5.2 Cost and Time Data

The total project budget was predicted at appraisal to be $696 million while project was done with final total cost of $753.73 million. For time aspect, according to project implementation schedule section in PCR document no time overrun was occurred in this project.

4.4.6 Road Overlay and Improvement Project

This project was constructed in Bangladesh. Based on ADB's published PCR document (Asian Development Bank, 2002):

4.4.6.1 Objectives

The project aimed to reach following objectives:

1) To reduce costs of transportation by utilizing simple cost-effective maintaining techniques and priority improvements of road;
2) To improve institutional skills to accomplish these kinds of operations;
3) To improve vehicle inspection abilities.

4.4.6.2 Cost and Time Data

The total project budget was predicted at appraisal to be $105.5 million while project was done with final total cost of $108.13 million. For time aspect, according to project implementation schedule section in PCR document 36% of time overrun was occurred and experienced in this project.

4.4.7 The Third Road Improvement Project

This project was constructed in Nepal. Based on ADB's published PCR document (Asian Development Bank, 2003):

4.4.7.1 Objectives

The project aimed to reach following objectives:

1) To contribute to the goals of government in related to the transportation cost reduction on the strategic network;
2) To help stimulate economic development;
3) To do poverty reduction in project-related-area;
4) To support strategy that government aims to improve and rehabilitate its strategic road network in order to putting the Project roads in an economically maintainable format;
5) To contribute to a reduction in total transport costs.

4.4.7.2 Cost and Time Data

The total project budget was predicted at appraisal to be $50 million while project was done with final total cost of $48.54 million. For time aspect, according to project implementation schedule section in PCR document 7% of time overrun was occurred and experienced in this project.

4.4.8 Transport Infrastructure Development Project

This project was constructed in New Guinea. Based on ADB's published PCR document (Asian Development Bank, 2002):

4.4.8.1 Objectives

The project aimed to reach following objective:

To reduce transportation costs and maintenance costs through improvement, modernizing, and expanding of transportation facilities in the country and improvement of maintenance facilities through training.

4.4.8.2 Cost and Time Data

The total project budget was predicted at appraisal to be $97 million while project was done with final total cost of $41.48 million. For time aspect, according to project implementation schedule section in PCR document 69% of time overrun was occurred and experienced in this project.

4.4.9 National Highways Project

This project was constructed in India. Based on ADB's published PCR document (Asian Development Bank, 2008):

4.4.9.1 Objectives

The project aimed to reach following objectives:

1) To assist the Government for improving the national highway system;
2) To have lower transportation costs in the project-related-areas, and transportation to ease move of goods and passengers more efficiently;
3) To generate job opportunities in industry section;
4) To upgrade the Government's institutional and implementation arrangements and construction supervision capabilities through a combination of international and domestic consultants working with the Executing Agency.

4.4.9.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 308.80 million while project was done with final total cost of $302.79 million. For time aspect, according to project implementation schedule section in PCR document 109% of time overrun was occurred and experienced in this project.

4.4.10 Transport Infrastructure Project

This project was constructed in Tonga. Based on ADB's published PCR document (Asian Development Bank, 2001):

4.4.10.1 Objectives

The project aimed to reach following objectives:

1) To upgrade about 50 kilometers (km) of key urban and rural roads, one of the international berths at the main port of Nuku'alofa;
2) To the facilities at eight interisland port sites in a cost-efficient, sustainable, and carefully prioritized manner.

4.4.10.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 12.5 million while project was done with final total cost of $13.31 million. For time aspect, according to project implementation schedule section in PCR document 12% of time overrun was occurred and experienced in this project.

4.4.11 Rural Infrastructure Development Project

This project was constructed in Nepal. Based on ADB's published PCR document (Asian Development Bank, 2004):

4.4.11.1 Objectives

The project aimed to reach following objectives:

1) To support the construction of rural infrastructures within Government's decentralization policy framework;
2) To make poverty reduction among the rural communities in the hill area.

4.4.11.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 16.9 million while project was done with final total cost of $15.6 million. For time aspect, according to project

implementation schedule section in PCR document 33% of time overrun was occurred and experienced in this project.

4.4.12 Bangkok Urban Transport Project

This project was constructed in Thailand. Based on ADB's published PCR document (Asian Development Bank, 2002):

4.4.12.1 Objectives

The project aimed to reach following objectives:

1) To increase institutional effectiveness in transportation planning and making policy and evaluation;
2) To enhance effectiveness of land utilization via appropriate accessibility and developments of roads in sectors with low level of development in Bangkok;
3) To develop a coherent road hierarchy west of the Chao Phraya River.

4.4.12.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 211 million while project was done with final total cost of $148.52 million. For time aspect, according to project implementation schedule section in PCR document 67% of time overrun was occurred and experienced in this project.

4.4.13 Second Road Improvement Project

This project was constructed in Vietnam. Based on ADB's published PCR document (Asian Development Bank, 2003):

4.4.13.1 Objectives

The project aimed to reach following objectives:

1) To improve long-term transportation efficiency and safety;
2) To have poverty reduction through improving accessibility to rural era.

4.4.13.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 273 million while project was done with final total cost of $164.2 million. For time aspect, according to project implementation schedule section in PCR document 20% of time overrun was occurred and experienced in this project.

4.4.14 Airports Improvement Project

This project was constructed in Lao. Based on ADB's published PCR document (Asian Development Bank, 2001):

4.4.14.1 Objectives

The project aimed to reach following objective:

To ease greater development in the Lao People's Democratic Republic via provision of civil aviation infrastructure to help reliable and safe all-weather operations for all airports-related project in the country.

4.4.14.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 44.8 million while project was done with final total cost of $89.9 million. For time aspect, according to project implementation schedule section in PCR document 26% of time overrun was occurred and experienced in this project.

4.4.15 Jing-Jiu Railway Technical Enhancement Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2000):

4.4.15.1 Objectives

The project aimed to reach following objectives:

1) To enhance the operational efficiency of the Jing-Jiu Railway by acquiring modern railway technology, including associated training;

2) To support the Ministry of Railways the Executing Agency for the Project, in formulating and implementing policy reforms to improve efficiency and to commercialize railway operations.

4.4.15.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 532 million while project was done with final total cost of $552.2 million. For time aspect, according to project implementation schedule section in PCR document 299% of time overrun was occurred and experienced in this project.

4.4.16 Southern Transport Development Project

This project was constructed in Sri Lanka. Based on ADB's published PCR document (Asian Development Bank, 2011):

4.4.16.1 Objectives

The project aimed to reach following objectives:

1) To perform as a catalyst for the growth of the economy of poor southern region, and increase safety of roads in country;
2) To reduce poverty by job availability and to health, education, and other social services.

4.4.16.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 295.90 million while project was done with final total cost of $906.47 million. For time aspect, according to project implementation schedule section in PCR document 117% of time overrun was occurred and experienced in this project.

4.4.17 Shenmu-Yanan Railways Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2006):

4.4.17.1 Objectives

The project aimed to reach following objectives:

1) To increase economic development;
2) To reduce poverty in the northern regions of Shaanxi Province.

4.4.17.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 795.50million while project was done with final total cost of $731.78 million. . For time aspect, according to project implementation schedule section in PCR document 4% of time overrun was occurred and experienced in this project.

4.4.18 Xieng Khouang Road Improvement Project

This project was constructed in Lao. Based on ADB's published PCR document (Asian Development Bank, 2006):

4.4.18.1 Objectives

The project aimed to reach following objectives:

1) Reduction in transportation costs;
2) To help the province by making economically viable, all-weather available roads to the rest of the Lao, mainly to most important market centers.

4.4.18.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 64.50.50million while project was done with final total cost of $60.74 million. For time aspect, according to project implementation schedule section in PCR document 80% of time overrun was occurred and experienced in this project.

4.4.19 Daxian–Wanxian Railway Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2006):

4.4.19.1 Objectives

The project aimed to reach following objective:

To support the economic development of northeast Sichuan via provision of economic facilities through transporting natural resources, people and industrial products.

4.4.19.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 360.50million while project was done with final total cost of $344.5 million. For time aspect, according to project implementation schedule section in PCR document 49% of time overrun was occurred and experienced in this project.

4.4.20 Third Road Upgrading (Sector) Project

This project was constructed in Fiji. Based on ADB's published PCR document (Asian Development Bank, 2015):

4.4.20.1 Objectives

The project aimed to reach following objectives:

1) To help the government to improve the efficiency of road sector services;
2) To increase private sector contribution;
3) To improve management of road assets and sector resources.

4.4.20.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 90.50million while project was done with final total cost of $168.83 million. For time aspect, according to project implementation schedule section in PCR document 148% of time overrun was occurred and experienced in this project.

4.4.21 Road Network Improvement Project

This project was constructed in Sri Lanka. Based on ADB's published PCR document (Asian Development Bank, 2009):

4.4.21.1 Objective

The project aimed to reach following objective:

To mobilize and simplify policies of sector and institutional volume to enable the effective planning and management of the whole road network in Sri Lanka to fulfill the necessities for achieving economy growth.

4.4.21.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 123.3million while project was done with final total cost of $183.1 million. For time aspect, according to project implementation schedule section in PCR document 40% of time overrun was occurred and experienced in this project.

4.4.22 Primary Roads Restoration Project

This project was constructed in Cambodia. Based on ADB's published PCR document (Asian Development Bank, 2006):

4.4.22.1 Objectives

The project aimed to reach following objectives:

1) To assist the Government to restore and improve defective sector of the primary road network;
2) To improve access to rural areas in particular;
3) To promote human and economic development;
4) To reduce road transportation cost to ease move of goods and passengers more efficiently;
5) To) increase the capacity of the Ministry of Public Works and Transport to manage and maintain the road network effectively.

4.4.22.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 88.1 million while project was done with final total cost of $86.96 million. For time aspect, according to project implementation schedule section in PCR document 65% of time overrun was occurred and experienced in this project.

4.4.23 Chongqing-Guizhou Roads Development Project (Leichong Expressway)

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2008):

4.4.23.1 Objectives

The project aimed to reach following objectives:

1) To support pro-poor economic growth and social development via income enhancement and poverty reduction in Chongqing via specific improving in the road system;
2) To improve the accessibility of industrial and agricultural businesses to markets and the southern ports;
3) To improve the accessibility of the rural community to market opportunities and social facilities;
4) To get investment through improved transport capacity;
5) To reduce existing road accidents on existing roads.

4.4.23.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 345 million while project was done with final total cost of $333.23 million. For time aspect, according to project implementation schedule section in PCR document 40% of time overrun was occurred and experienced in this project.

4.4.24 Southern Yunnan Road Development Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2006):

4.4.24.1 Objectives

The project aimed to reach following objectives:

1) Supporting southern part of Yunnan by economic and social developments by eliminating a key road transport blockage between Yuanjiang and Mohei;
2) To help provide a situation that decrease the poverty via provision of better accessibility to economic mainstream for poor communities;
3) To promote and extend sector reforms initiated under previous ADB-financed projects.

4.4.24.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 770.3 million while project was done with final total cost of $985.5 million. For time aspect, according to project implementation schedule section in PCR document 46% of time overrun was occurred and experienced in this project.

4.4.25 Greater Mekong Subregion: Cambodia Road Improvement Project

This project was constructed in Cambodia. Based on ADB's published PCR document (Asian Development Bank, 2011):

4.4.25.1 Objectives

The project aimed to reach following objectives:

1) To promote economic operations and ease the trades between Cambodia, Thailand, and Viet Nam in order to support poverty reduction along the Southern Economic Corridor;

2) To reduce poverty by providing all-year, all-weather road access to employment opportunities, markets, and growth centers in the Northwest;
3) To improve social facilities with provision of all-year all-weather road access to education and health;
4) To promote economic growth through and promoting h cost reduction reducing the road transportation reliability.

4.4.25.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 77.50million while project was done with final total cost of $86.97 million. For time aspect, according to project implementation schedule section in PCR document 58% of time overrun was occurred and experienced in this project.

4.4.26 Rural Access Roads Project

This project was constructed in Lao. Based on ADB's published PCR document (Asian Development Bank, 2008):

4.4.26.1 Objectives

The project aimed to reach following objectives:

1) To assist the Government aiming at poverty reduction through improvement of rural accessibility in four provinces;
2) Providing access and road maintenance to marketplace, education, and health services, and with chances for transport service, for inaccessible residents of villages in the affected areas.

4.4.26.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 37.5 million while project was done with final total cost of $27.48 million. For time aspect, according to project

implementation schedule section in PCR document 47% of time overrun was occurred and experienced in this project.

4.4.27 Roads for Rural Development Project

This project was constructed in Lao. Based on ADB's published PCR document (Asian Development Bank, 2014):

4.4.27.1 Objectives

The project aimed to reach following objectives:

1) To induce economic development and social integration;
2) To make a connection between all districts with the aim of poverty reduction;
3) To enhance accessibility to acceptable, trustable, cost effective, and safe all-year road transportation services in isolated rural area.

4.4.27.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 39.2 million while project was done with final total cost of $49.46 million. For time aspect, according to project implementation schedule section in PCR document no time overrun was occurred in this project.

4.4.28 Shaanxi Roads Development Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2010):

4.4.28.1 Objectives

The project aimed to reach following objectives:

1) To accelerate economic development in Shaanxi Province;
2) To improve accessibility of agricultural and industrial-related-products to markets;

3) To improve accessibility to economic opportunities, job, and social facilities for rural communities;
4) To get investment via transportation cost reduction n project-related-area;
5) To reduce existing road accidents.

4.4.28.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 757 million while project was done with final total cost of $965.5 million. For time aspect, according to project implementation schedule section in PCR document no time overrun was occurred in this project.

4.4.29 Road Sector Development Project

This project was constructed in Sri Lanka. Based on ADB's published PCR document (Asian Development Bank, 2009):

4.4.29.1 Objectives

The project aimed to reach following objectives:

1) Improvement of transportation performance and contributing to the growth of economic occasions and reducing the poverty through improving national and local road institutions' capability to carry out their main role of strategically management and planning of the road systems and networks;
2) To develop powerful, competitive local capability for road construction and engineering services;
3) To increase the capacity of priority roads.

4.4.29.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 92.5 million while project was done with final total cost of $102.1 million. For time aspect, according to project

implementation schedule section in PCR document 15% of time overrun was occurred and experienced in this project.

4.4.30 Western Transport Corridor Project

This project was constructed in India. Based on ADB's published PCR document (Asian Development Bank, 2014):

4.4.30.1 Objectives

The project aimed to reach following objectives:

1) To remove capacity constraints on a critical section of the project highway along the Western Transport Corridor;
2) To enhance road safety via designing the features that leads to traffic accidents minimization of negative effects of road construction on the community in project-related-area;
3) To increase contribution of private sector with the aim of development and maintaining the national highway system.

4.4.30.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 378 million while project was done with final total cost of $460.4 million. For time aspect, according to project implementation schedule section in PCR document 179% of time overrun was occurred and experienced in this project.

4.4.31 Road Sector Development Program

This project was constructed in Pakistan. Based on ADB's published PCR document (Asian Development Bank, 2010):

4.4.31.1 Objectives

The project aimed to reach following objectives:

1) Enhancing access of the rural community to markets and social services;

2) To improve and rehabilitee the rural accessibility roads network;
3) To keep main road assets through rationalization of road maintenance process;
4) To improve important provincial highways for easing trade and better income generation, job opportunities in order to effectiveness of the Sindh Communication.

4.4.31.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 236 million while project was done with final total cost of $195.33 million. For time aspect, according to project implementation schedule section in PCR document 33% of time overrun was occurred and experienced in this project.

4.4.32 West Bengal Corridor Development Project

This project was constructed in India. Based on ADB's published PCR document (Asian Development Bank , 2012):

4.4.32.1 Objectives

The project aimed to reach following objectives:

1) To support the development of a transport corridor in West Bengal to promote sub regional economic activities, reduce poverty;
2) To facilitate trade through cutting serious capacity limitations off and improvement of transportation efficiency.

4.4.32.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 323 million while project was done with final total cost of $133.6 million. For time aspect, according to project implementation schedule section in PCR document 62% of time overrun was occurred and experienced in this project.

4.4.33 Western Yunnan Roads Development Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2011):

4.4.33.1 Objectives

The project aimed to reach following objectives:

1) To eliminate transportation obstacles and to decrease cost of transportation in western Yunnan;
2) Promoting pro-poor economic development and reducing poverty;
3) Contributing in regional development in the project area.

4.4.33.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 582million while project was done with final total cost of $766.7million. For time aspect, according to project implementation schedule section in PCR document 33% of time overrun was occurred and experienced in this project.

4.4.34 Road Network Project

This project was constructed in Bhutan. Based on ADB's published PCR document (Asian Development Bank, 2013):

4.4.34.1 Objectives

The project aimed to reach following objectives:

1) To develop safe, reliable, efficient, and affordable passenger;
2) To freight transport facilities.

4.4.34.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 34.1 million while project was done with final total cost of $36.29 million. For time aspect, according to project

implementation schedule section in PCR document 35% of time overrun was occurred and experienced in this project.

4.4.35 Road Rehabilitation Project

This project was constructed in Tajikistan. Based on ADB's published PCR document (Asian Development Bank, 2008):

4.4.35.1 Objectives

The project aimed to reach following objectives:

1) Enhancing income and reducing poverty in Khatlon region by improving road transport infrastructure;
2) To support making productive employment generation.

4.4.35.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 26.8 million while project was done with final total cost of $36.29 million. For time aspect, according to project implementation schedule section in PCR document 29% of time overrun was occurred and experienced in this project.

4.4.36 Guangxi Roads Development Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2008):

4.4.36.1 Objectives

The project aimed to reach following objectives:

1) Promoting pro-poor economic development in Guangxi through easing trade and bringing the investment to the project region;
2) To reduce poverty via improvement of living standards and employment creation in project-related-area;

3) Providing more transportation volume, easing congestion, traffic accidents and vehicle emissions reduction, and lower motor vehicle operating costs.

4.4.36.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 455.2million while project was done with final total cost of $465.3 million. For time aspect, according to project implementation schedule section in PCR document 37% of time overrun was occurred and experienced in this project.

4.4.37 Xi'an Urban Transport Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2011):

4.4.37.1 Objectives

The project aimed to reach following objective:

To promote economic growth in Xi'an through transport cost reduction costs and relieving transport infrastructure bottlenecks.

4.4.37.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 762 million while project was done with final total cost of $1,333 million. For time aspect, according to project implementation schedule section in PCR document 50% of time overrun was occurred and experienced in this project.

4.4.38 Ningxia Roads Development Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2013):

4.4.38.1 Objectives

The project aimed to reach following objectives:

1) To increase transportation capacity and efficiency of freight and passenger movements;
2) To provide poor counties/districts with better access to markets and social services have been achieve.

4.4.38.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 611.8 million while project was done with final total cost of $865 million. For time aspect, according to project implementation schedule section in PCR document 60% of time overrun was occurred and experienced in this project.

4.4.39 Gansu Roads Development Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2013):

4.4.39.1 Objectives

The project aimed to reach following objectives:

1) Promoting economic development;
2) To reduce poverty in eastern Gansu province through reduction of cost transportation; facilities traffic congestion, and improvement accessibility in the project-related-area;

4.4.39.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 882 million while project was done with final total cost of $1341 million. For time aspect, according to project implementation schedule section in PCR document 36% of time overrun was occurred and experienced in this project.

4.4.40 Central Sichuan Roads Development Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2014):

4.4.40.1 Objectives

The project aimed to reach following objectives:

1) To develop an integrated road transport system to support sustainable economic development in Sichuan;
2) Traffic accidents and motor vehicle operational costs reduction;
3) Improving accessibility between Kunming and Chengdu;
4) Provide more transportation volume to be capable of growing traffic;
5) Improving job, marketplace, and social service accessibility services.

4.4.40.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 2077 million while project was done with final total cost of $3,102.63 million. For time aspect, according to project implementation schedule section in PCR document no time overrun was experienced in this project.

4.4.41 National Highway Corridor (Sector) I Project

This project was constructed in India. Based on ADB's published PCR document (Asian Development Bank, 2015):

4.4.41.1 Objectives

The project aimed to reach following objective:

To help the government reinforce the policy and institutional framework for efficient delivery of highway development and operation and maintenance services.

4.4.41.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 760 million while project was done with final total cost of $1,137.3 million. For time aspect, according to project implementation schedule section in PCR document 114% of time overrun was occurred and experienced in this project.

4.4.42 Chongqing-Guizhou Roads Development Project (Chongzun Expressway)

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2008):

4.4.42.1 Objectives

The project aimed to reach following objectives:

1) To support pro-poor economic growth and social development by income enhancement;
2) To have poverty reduction in Guizhou Province by improving road system.

4.4.42.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 834 million while project was done with final total cost of $809 million. For time aspect, according to project implementation schedule section in PCR document 40% of time overrun was occurred and experienced in this project.

4.4.43 Dushanbe–Kyrgyz Border Road Rehabilitation Project (Phase 1)

This project was constructed in Tajikistan. Based on ADB's published PCR document (Asian Development Bank, 2010):

4.4.43.1 Objectives

The project aimed to reach following objectives:

1) To reduce poverty through road transportation cost;
2) To improve access to marketplaces;

3) Enhancement of local trade and support by rehabilitating the road connecting Dushanbe to Nurobod (Darband) in the Rasht Valley and on to the Kyrgyz and China.

4.4.43.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 23.6 million while project was done with final total cost of $ 23.3 million. For time aspect, according to project implementation schedule section in PCR document 28% of time overrun was occurred and experienced in this project.

4.4.44 Guangxi Roads Development II Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2011):

4.4.44.1 Objectives

The project aimed to reach following objectives:

1) To have low level of transportation costs by economic growth promotion;
2) To reduce poverty in the project-related- area.

4.4.44.2 Cost and Time Data

The total project budget was predicted at appraisal to be 726 million while project was done with final total cost of $ 809.4 million. For time aspect, according to project implementation schedule section in PCR document 25% of time overrun was occurred and experienced in this project.

4.4.45 Hunan Roads Development II Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2012):

4.4.45.1 Objectives

The project aimed to reach following objectives:

1) To facilitate productive, sustainable economic growth;
2) To contribute to reducing poverty in Hunan.

4.4.45.2 Cost and Time Data

The total project budget was predicted at appraisal to be 778.1 million while project was done with final total cost of $ 989.72 million. For time aspect, according to project implementation schedule section in PCR document no time overrun was experienced in this project.

4.4.46 Regional Road Development Project

This project was constructed in Mongolia. Based on ADB's published PCR document (Asian Development Bank, 2015):

4.4.46.1 Objectives

The project aimed to reach following objectives:

1) To promote regional cooperation and sustainable economic growth in Mongolia by improving transport efficiency and safety for domestic and international traffic on the country's north–south corridor;
2) To construct a 427 km paved road between Choir and the border with the PRC;
3) To implement a cross-border road transport facilitation plan and improve road safety.

4.4.46.2 Cost and Time Data

The total project budget was predicted at appraisal to be 78.14 million while project was done with final total cost of $ 153.01 million. For time aspect, according to project implementation schedule section in PCR document 122% of time overrun was occurred and experienced in this project.

4.4.47 East–West Highway Improvement Project

This project was constructed in Azerbaijan. Based on ADB's published PCR document (Asian Development Bank, 2011):

4.4.47.1 Objectives

The project aimed to reach following objectives:

1) To complete, a total of 94.0 km of roads along the east–west highway;
2) To significantly improve connectivity in the project area, as well as traffic between Azerbaijan and Georgia.

4.4.47.2 Cost and Time Data

The total project budget was predicted at appraisal to be 93.2 million while project was done with final total cost of $ 137.6 million. For time aspect, according to project implementation schedule section in PCR document 17% of time overrun was occurred and experienced in this project.

4.4.48 Chhattisgarh State Roads Development Sector Project

This project was constructed in India. Based on ADB's published PCR document (Asian Development Bank, 2014):

4.4.48.1 Objectives

The project aimed to reach following objectives:

1) To support economic growth;
2) To reduce poverty through accessibility to development opportunities and social services that includes education and health.

4.4.48.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 285.7 million while project was done with final total cost of $ 281.75 million. For time aspect, according to project

implementation schedule section in PCR document 58% of time overrun was occurred and experienced in this project.

4.4.49 North-West Frontier Province Road Development Sector and Sub regional Connectivity Project

This project was constructed in Pakistan. Based on ADB's published PCR document (Asian Development Bank, 2012):

4.4.49.1 Objectives

The project aimed to reach following objectives:

1) To achieve regional policy improvements and institutional strengthening to improve supervision of the road subsector;
2) To accomplish a district roads enhancement, including rehabilitation and enhancement of 212 Km of district highways and about 700 km of country side access roads in project area;
3) To accomplish a sub-regional linking enhancement module, including construction and enhancement of about 310 km of national freeways and infrastructures at 2 different border points with Afghanistan.

4.4.49.2 Cost and Time Data

The total project budget was predicted at appraisal to be $423.6 million while project was done with final total cost of $ 300.5 million. For time aspect, according to project implementation schedule section in PCR document 33% of time overrun was occurred and experienced in this project.

4.4.50 Southern Transport Corridor Road Rehabilitation Project

This project was constructed in Kyrgiz. Based on ADB's published PCR document (Asian Development Bank, 2011):

4.4.50.1 Objectives

The project aimed to reach following objective:

To promote economic growth and poverty reduction through rehabilitation of part of the Osh–Sary-Tash–Irkeshtam road that leads to reduction of transport costs, improvement of access to markets, and enhancement of regional trade.

4.4.50.2 Cost and Time Data

The total project budget was predicted at appraisal to be $43.4 million while project was done with final total cost of $ 43.33 million. For time aspect, according to project implementation schedule section in PCR document 18% of time overrun was occurred and experienced in this project.

4.4.51 Central Yunnan Roads Development Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2015):

3.2.51.1 Objectives

The project aimed to reach following objectives:

1) To promote sustainable economic growth in central Yunnan through transportation cost reduction promote access to the market and social services;
2) To contribute to development of the region in the Greater Mekong Subregion (GMS) through constructing the last link of the Chengdu to Kunming national high-priority western development corridor;

4.4.51.2 Cost and Time Data

The total project budget was predicted at appraisal to be $745 million while project was done with final total cost of $ 1110.3 million. For time aspect, according to project implementation schedule section in PCR document 20% of time overrun was occurred and experienced in this project.

4.4.52 Andkhoy–Qaisar Road Project

This project was constructed in Afghanistan. Based on ADB's published PCR document (Asian Development Bank, 2010):

4.4.52.1 Objectives

The project aimed to reach following objectives:

1) Reduction of poverty;
2) To promote economic and social development by supporting the government to reestablish the primary road damaged network.

4.4.52.2 Cost and Time Data

The total project budget was predicted at appraisal to be $80 million while project was done with final total cost of $ 82.49 million. For time aspect, according to project implementation schedule section in PCR document 114% of time overrun was occurred and experienced in this project.

4.4.53 Madhya Pradesh State Roads Sector Project II

This project was constructed in India. Based on ADB's published PCR document (Asian Development Bank, 2015):

4.4.53.1 Objectives

The project aimed to reach following objective:

To improve transportation efficiency of the state road network in Madhya Pradesh, this contributes to the poverty reduction.

4.4.53.2 Cost and Time Data

The total project budget was predicted at appraisal to be $400 million while project was done with final total cost of $ 387 million. For time aspect, according to project implementation schedule section in PCR document 54% of time overrun was occurred and experienced in this project.

4.4.54 Eastern Sichuan Roads Development Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2014):

4.4.54.1 Objectives

The project aimed to reach following objective:

To develop an integrated road transport system that supports sustainable economic growth in Sichuan Province.

4.4.54.2 Cost and Time Data

The total project budget was predicted at appraisal to be $1425 million while project was done with final total cost of $ 1728.7 million. For time aspect, according to project implementation schedule section in PCR document no time overrun was experienced in this project.

4.4.55 Hunan Roads Development III Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2014):

4.4.55.1 Objectives

The project aimed to reach following objectives:

1) To promote sustainable economic growth;
2) To make poverty reduction in Hunan province in the project-related-area particularly.

4.4.55.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 519.51 million while project was done with final total cost of $ 898.09 million. For time aspect, according to project implementation schedule section in PCR document 8% of time overrun was occurred and experienced in this project.

4.4.56 Dushanbe–Kyrgyz Border Road Rehabilitation Project, Phase II

This project was constructed in Tajikistan. Based on ADB's published PCR document (Asian Development Bank, 2013):

4.4.56.1 Objectives

The project aimed to reach following objectives:

1) To achieve better and sustainable regional and national road networks;
2) To bring socio-economic advantages to local communities along these roads.

4.4.56.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 64.5 million while project was done with final total cost of $ 59.93 million. For time aspect, according to project implementation schedule section in PCR document 13% of time overrun was occurred and experienced in this project.

4.4.57 Heilongjiang Road Network Development Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2012):

4.4.57.1 Objectives

The project aimed to reach following objectives:

1) To promote sustainable economic growth by improving the Jixi-Nehe highway;
2) To comprise the upgrading of 428 km of the Jixi-Nehe highway;
3) To improve rural link roads, totaling 170 km.

4.4.57.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 524.55 million while project was done with final total cost of $ 538.19 million. For time aspect, according to project

implementation schedule section in PCR document no time overrun was experienced in this project.

4.4.58 Western Guangxi Roads Development Project

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2014):

4.4.58.1 Objectives

The project aimed to reach following objective:

To involve to growth of pro-poor sustainable economy in western Guangxi and northern Vietnam by expansion of an efficient, safe, and green local transportation system in order to promote trade in western Guangxi.

4.4.58.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 1,566million while project was done with final total cost of $ 1998.2 million. For time aspect, according to project implementation schedule section in PCR document 15% of time overrun was occurred and experienced in this project.

4.4.59 North–South Corridor Project

This project was constructed in Afghanistan. Based on ADB's published PCR document (Asian Development Bank, 2013):

4.4.59.1 Objectives

The project aimed to reach following objectives:

1) Rehabilitate 140 km of the Mazar-e-Sharif - Dara-i-Suf road and 99 km of the Bamian-Yakawlang road;
2) To equip cross-border equipment in Spin Boldak;
3) To get support to manage and monitor the project.

4.4.59.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 140 million while project was done with final total cost of $ 175.13 million. For time aspect, according to project implementation schedule section in PCR document 62% of time overrun was occurred and experienced in this project.

4.4.60 Xinjiang Regional Road Improvement Project (Korla–Kuqa Section)

This project was constructed in China. Based on ADB's published PCR document (Asian Development Bank, 2014):

4.4.60.1 Objectives

The project aimed to reach following objectives:

1) To facilitate development of national and regional transportation system in Xinjiang more efficiently;
2) To get result in a more sustainable east-west road corridor in Xinjiang that is more efficient in terms of economy, social services, having integration with eastern China.

4.4.60.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 594 million while project was done with final total cost of $ 569 million. For time aspect, according to project implementation schedule section in PCR document 20% of time overrun was occurred and experienced in this project.

4.4.61 Carec Transport Corridor 1 (Bishkek–Torugart Road) Project

This project was constructed in Kirgizstan. Based on ADB's published PCR document (Asian Development Bank, 2013):

4.4.61.1 Objectives

The project aimed to reach following objectives:

1) To reduce cost of transportation;
2) To develop regional trade among the Kyrgyz Republic and China.

4.4.61.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 30.3 million while project was done with final total cost of $ 21.13 million. For time aspect, according to project implementation schedule section in PCR document 55% of time overrun was occurred and experienced in this project.

4.4.62 CAREC Regional Road Corridor Improvement Project

This project was constructed in Kirgizstan Republic. Based on ADB's published PCR document (Asian Development Bank, 2014):

4.4.62.1 Objectives

The project aimed to reach following objectives:

1) Reduction in transportation cost and developing and trade in regional level among Kyrgyz, China, Tajikistan, and other Central Asian countries;
2) To improve corridor's disappeared links by development and enhancement of the about 263km double lane road from Sary Tash in the Kyrgyz to Nimich in Tajikistan

4.4.62.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 39.50 million while project was done with final total cost of $ 64.48 million. For time aspect, according to project implementation schedule section in PCR document 4% of time overrun was occurred and experienced in this project.

4.4.63 Second Road Rehabilitation and Improvement Project

This project was constructed in Nepal. Based on ADB's published PCR document (Asian Development Bank, 2014):

4.4.63.1 Objectives

The project aimed to reach following objectives:

Enhancing road network and road management quality by:

1) Improvement in governance and increasing road management capacity;
2) Improving projected road corridors;

4.4.63.2 Cost and Time Data

The total project budget was predicted at appraisal to be $ 64.60 million while project was done with final total cost of $ 81.70 million. For time aspect, according to project implementation schedule section in PCR document 46% of time overrun was occurred and experienced in this project.

Chapter 5

DATA ENVELOPMENT ANALYSIS (DEA)

5.1 Introduction

In this chapter, Data Envelopment Analysis is introduced as a tool which used in this study for measuring the relative performance of project managers in controlling cost and time of construction projects. Following that the data used and relevant tables are provided.

5.2 Significance of Performance Measurement in Construction Industry

Performance or efficiency measurement is a substantial feature for clients, contractors and consultants in construction industry to assess their actual outcomes against planned objectives. It should be done to ensure that the institute or company is doing well in the projected works and management. Due to this reason quantifying efficiency has become more significant to the construction industry as a further and another method of refining their business and attaining more success level.

5.3 What is DEA?

“Data Envelopment Analysis (DEA) is a powerful service management and benchmarking technique developed by Charnes, Cooper, and Rhodes (CCR) in 1978 to evaluate non-profit, and public-sector organizations (Charnes, Cooper, & Rhodes, 1978).” Since its inception, this method has been used to identify ways of improving services that are not visible using other techniques. It is an evaluation tool for a set of

entities called decision making units (DMUs) with multiple inputs and multiple outputs. It is also a decision-making tool that measures the relative efficiency of comparable units. The CCR model is the first and most fundamental DEA model to evaluate the relative efficiency of DMUs.

Consider a set of homogenous DMUs as *DMU$_j$ (j=1,..., n)*. Each DMU consumes *m* inputs to produce *r* outputs. Suppose that $X_j = (x_{1j},...,x_{mj})$ and $Y_j = (y_{1j},...,y_{rj})$ are vectors of input and output values for *DMU$_j$*, respectively, and let $X_j \geq 0$ and $Y_j \geq 0, Y_j \neq 0$. The Production Possibility Set (PPS) T_C can be constructed by considering the following postulates.

The observed activities $(X_j, Y_j) \quad j = 1,2,\ldots n$ belong to T_C;

If an activity *(X, Y)* belongs to T_C, then activity *(tX, tY)* belongs to T_C for any positive scalar *t*. This property is called the constant returns-to-scale assumption;

For any activity *(X, Y)* in T_C, any semi-positive activity $(\overline{X}, \overline{Y})$ with $\overline{X} \geq X$ and $\overline{Y} \leq Y$ is included in T_C.

Any convex combination of activities in T_C belongs to T_C;

T_C is the smallest set that satisfies the above four properties.

With respect to the above assumptions, T_C can be defined as follows:

$$T_C = \{(X,Y) \mid X \geq \sum_{j=1}^{n} \lambda_j X_j,\ Y \leq \sum_{j=1}^{n} \lambda_j Y_j, \lambda_j \geq 0, \forall j\} \tag{1}$$

Now, for the evaluation of DMUs, DMU_o with (X_0, Y_0) as the input–output vector is written from an input orientation with some free value θ such that $(\theta X_0, Y_0)$ belongs to PPS. Thus,

$$\begin{aligned} &Min \quad \theta \\ &S.t \quad (\theta X_0, Y_0) \in T_C \end{aligned} \tag{2}$$

Based on the definition of T_C, the following linear programming problem is obtained:

$$\begin{aligned} &Min \quad \theta \\ &S.t \quad -\sum_{j=1}^{n} \lambda_j X_j + \theta X_0 \geq 0 \\ &\qquad \sum_{j=1}^{n} \lambda_j Y_j \geq Y_0 \\ &\qquad \lambda_j \geq 0,\ j = 1, \ldots, n. \\ &\qquad \theta \ free \end{aligned} \tag{3}$$

The dual of the above linear programming problem is used to obtain values for the input weights v_i and the output weights u_r:

$$\begin{aligned} &Max \quad \theta = \sum_{r=1}^{s} u_r y_{ro} \\ &s.t \quad \sum_{i=1}^{m} v_i x_{io} = 1 \\ &\qquad \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \quad j = 1,2,\ldots,n \\ &\qquad v_i \geq 0 \quad i = 1,2,\ldots,m \\ &\qquad u_r \geq 0 \quad i = 1,2,\ldots,s \end{aligned} \tag{4}$$

In vector format, this can be written as follows:

$$\begin{aligned} &Max \quad \theta = UY_o \\ &s.t \quad VX_o = 1 \\ &\qquad UY_j - VX_j \leq 0 \quad j = 1,2,\ldots,n \\ &\qquad U \geq 0 \\ &\qquad V \geq 0 \end{aligned} \tag{5}$$

DMU_o is said to be CCR-efficient if $\theta^* = 1$ and there exists at least one optimal (V^*, U^*) with $V^* > 0$ and $U^* > 0$. DMU_o is said to be CCR-weak efficient if $\theta^* = 1$ and there exists $V^* \geq 0$ and $U^* \geq 0$ where at least one of V^* or U^* is equal to zero. Otherwise, DMU_o is CCR-inefficient, that is, $\theta^* \neq 1$.

Clearly, the optimal solution for both (3) and (4) is the same, which shows the efficiency value of the evaluation of DMU_o (X_0, Y_0). The optimal solutions of these models give us other useful information about DMU_o.

Assume that DMU_o (X_0, Y_0) is evaluated by model (3) and $\lambda^* = (\lambda_i^*, \dots, \lambda_j^*, \dots \lambda_n^*)$ with an objective function value of θ^* as its optimal solution. In vector λ^* , $\lambda_j^* > 0$ shows the effect of DMU_j in θ^* toward the efficiency value of DMU_o. Then, DMU_j can be considered as a benchmark in the efficiency improvement process of DMU_o. Alternatively, if it is assumed that (U^*, V^*) with an objective function of θ^* is the optimal solution of model (4) for DMU_o (X_0, Y_0), u_r^* $(r = 1, \dots, s)$ and v_i^* $(i = 1, \dots, m)$ can be considered as the weight or degree of importance of the r^{th} output and i^{th} input, respectively, in the efficiency value. Similarly, models based on variable returns-to-scale (Banker, Charnes, & Cooper, 1984) may be used for this purpose.

Obviously, if u_r^* or v_i^* are equal to zero, the associated output or input has no effect on the efficiency of DMU_o (Cooper, Seiford, & Tone, 2007).

One of the proposed methods for understanding the importance of inputs and outputs in the DMU efficiency values is to compute the average of the optimal weight values for u_r^* and v_i^* and compare these average values. Another significant method for the sensitivity analysis is to eliminate the inputs and outputs one by one, and compute the efficiency of the DMUs with the remaining inputs and outputs. Any decrement in the average efficiency value of a DMU shows the degree of importance of the eliminated input or output (Montoneri, Lin, Lee, & Huang, 2012).

Furthermore, the sensitivity analysis for individual efficient DMUs may be employed to retain their efficiency against small changes in input or output values (Daneshvar, Izbirak, & Javadi, 2014).

In this study, constant returns-to-scale are assumed for the evaluation of the observed DMUs. This is because the inherent nature of the construction industry means that increasing the number of contributing causes will increase the potential cost and time overrun.

5.4 Advantages of DEA

The efficiency of an equipment or a facility can be computed by comparing its real output to its engineering output. On the other hand, when it is considered a service by an organization, or a company it is generally not known that what is the best efficiency is. Due to that reason determination of whether the provided service by the contractor is absolutely efficient is difficult. DEA enables researchers and companies to compare different number of contractors, projects and services with each other and compute their relative efficiency. A different DEA advantage that attracts investigators and project managers is its capability to recognize the probable improvement for individual inefficient DMUs. (Sowlati & Paradi, 2004)

5.5 Sensitivity Analysis

In a defined condition and assuming the other variables are constant, change in dependent variable according to change in the value of independent value is called sensitivity.

Accordingly, sensitivity analysis is defined as an investigation which studies the alteration in output variables based on the change in input statistical model. In other

words, it is a way of modifying the inputs of a statistical model in an organized way to predict the effects of these changes on the output of the model. In brief, sensitivity analysis can be defined as change the model and notice the behavior.

Step by step sensitivity analysis can be termed as followings:

1) Definition the output and input of the model;
2) Selection of the input for which the analysis is to be measured and keeping the rest of inputs constant;
3) Computation of the value for output while the value of input is changing;
4) Calculation of the change in output as a result of change in selected input;
5) Continuing to steps 2 to 4 for each of the remaining output up to the last input.

Results of the analysis will show the influence of each of the inputs on the output. In another words, results will show that in what extent the output is sensitive to the amount of change for each of input variables (Saltelli, Tarantola, Francesca, & Ratto, 2004).

5.5.1 Advantages of Sensitivity Analysis

Sensitivity analysis is an in depth analysis. After performing sensitivity analysis, every single dependent and independent variables are studied in depth. The aim of the sensitivity analysis is to answer the question that how independent variable affects dependent variable by the mean of sensitivity analysis. Moreover, it gives an understanding about the relationship concerning the variables, the cause and effect reaction between the two types of variables. Outcome of this method will give better future prediction ability. Furthermore, since sensitivity analysis studies every single of variables individually, it can recognize critical variables that may perform as a major

problem. In addition, by sensitivity analysis, decision maker will be able to distinguish which variables impacting higher in the success or failure direction. (Borad, 2018)

Chapter 6

DATA ANALYSIS AND FINDINGS

6.1 Introduction

In this chapter, findings of comprehensive studies on large-scale construction projects including, identification of adverse causes and reasons of delay and cost overrun on those projects are written. Thereafter results of relative time and cost management efficiency and sensitivity analysis computed by DEA, are written and discussed.

6.2 Large Construction Projects

After performing an inclusive literature review on time and cost overrun and their causes in previous and current researches, a set of eighty large construction projects supported by ADB for an in depth investigation were obtained. Then, projects that faced one of time or cost overrun or both of them in the same time were selected for an in depth investigation for adverse causes. Due to this reason the number of studied projects decreased into sixty-three. Distribution of total estimated cost of studied projects is depicted in Figure 3.

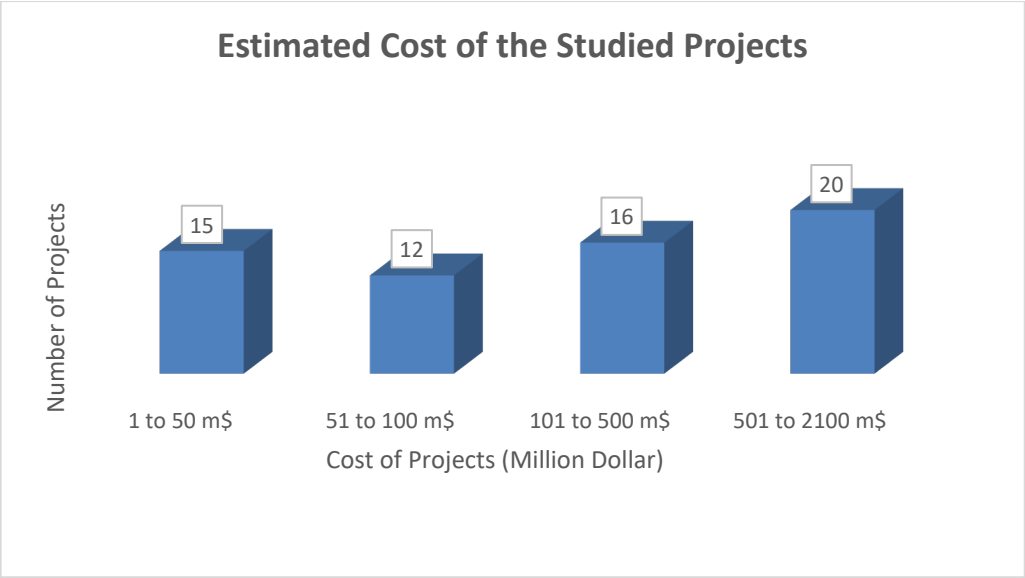

Figure 3: Number of studied projects in terms of their estimated cost in appraisal

As can be seen in the figure 3 and Table 5, the statistical distribution of the projects under study is as follows:

1) Numerically, the largest number of studied projects is over $ 501 million Dollar;
2) Estimated or primary cost of studied projects are in between 12.5 million Dollar and 2100 million Dollar;
3) More than half of studied projects cost above 100 million Dollar;
4) The least cost is project 10 with twelve point five million Dollar and the most expensive project is project 40 with 2077 million Dollar.

After that, based on the obtained data, magnitude of cost overrun and delay for every single project was separately calculated, tabulated and depicted. For more information about title of projects, their location and completion date of projects refer to Table 1 and chapter 5.

According to Table 5, the highest amount of cost overrun were occurred in project 16 with 206%, and thereafter project number 14, 46, 20 and 37 respectively. Moreover, the uppermost time overrun were occurred in project number 15 with about 3005 of time overrun and thereafter project number 30, 20, 46 and 16 respectively. It can be noticed that, projects number 16, 20 and 46 are listed in first five projects with highest time and cost overrun percentages. It shows the high amount of correlation in between time overrun and cost overrun when it comes to large amount of overrun.

Table 5: Time and cost overrun in selected ADB projects

Project	Estimated Cost $(Million)	Cost Overrun (%)	Estimated Duration (Days)	Time Overrun (%)
01	15.60	10.71	624	92
02	15.34	29.20	528	41
03	178	-12.07	648	48
04	23.75	6.32	1369	49
05	696	8.29	1581	0
06	105.5	2.49	792	36
07	50	-3	1613	7
08	97	-57	1886	69
09	308.8	-2	1340	109
10	12.5	6.48	1552	12
11	16.9	-8	2190	33
12	211	-30	2190	67
13	237	-31	1742	20
14	44.8	101	1217	26
15	532	4	228	299
16	295.9	206	2160	117
17	795.5	-8	2555	4
18	50	21	1800	80
19	360	-4	1490	49
20	90	88	2283	148
21	123.3	48	1825	40
22	88.1	-1	1200	65
23	345	-3.41	1798	40
24	770.3	28	1796	46
25	77.5	12	1200	58
26	37.5	-27	1551	47
27	39.2	26	2880	-6
28	757	28	1440	0
29	92.5	10	1824	15

30	378	21.80	1440	179
31	236	-17	2190	33
32	92	45	2371	62
33	582	32	1490	33
34	34.10	6	1825	35
35	26.8	3	1460	29
36	455.2	2	1492	37
37	762	75	1643	50
38	611.8	41	1875	60
39	882	52	2010	36
40	2077	49	2190	0
41	649	53	1440	114
42	834	-3	1826	40
43	23.6	-1	1216	28
44	726	11	1339	25
45	778.1	27	1825	-13
46	78.14	96	1642.5	122
47	93.2	47.64	1094	17
48	285.7	-1	1825	58
49	423.6	-29	1095	33
50	43.4	0	1065	18
51	745	49.03	1826	20
52	80	3.11	940	114
53	400	-3.25	1186	54
54	1425	21.31	1642.5	0
55	519.51	73	2281	8
56	64.5	-7.09	2100	13
57	524.55	2.60	1398	0
58	1566	27.60	1825	15
59	140.9	24.41	1260	62
60	594	-4.97	1855	20
61	30.3	-30	1002	55
62	76.5	-7	2191	4
63	64.60	26.47	1525	46

In line with the obtained data in the above table, Figure 4 and Figure 5 are showing the distribution of time and cost overrun in four different levels. As indicated in figures, about half (32 out of 63) of the studied projects experienced cost overrun up to 50% while about 12% of studied projects experiencing cost overrun more than 50%.

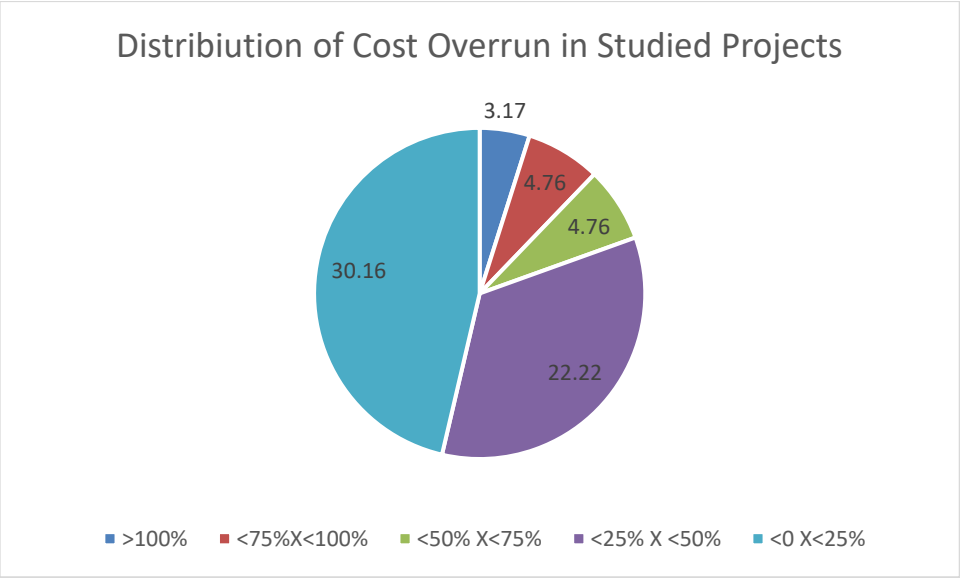

Figure 4: Distibution of cost overrun in studied projects

In time aspect, according to the Figure 5, most of the studied projects experienced time overrun between 25% and 50%. Also more than 30% of studied projects experienced delays more than 50% of estimated time. It should be stated that 60 out of 62 studied projects experienced time overrun.

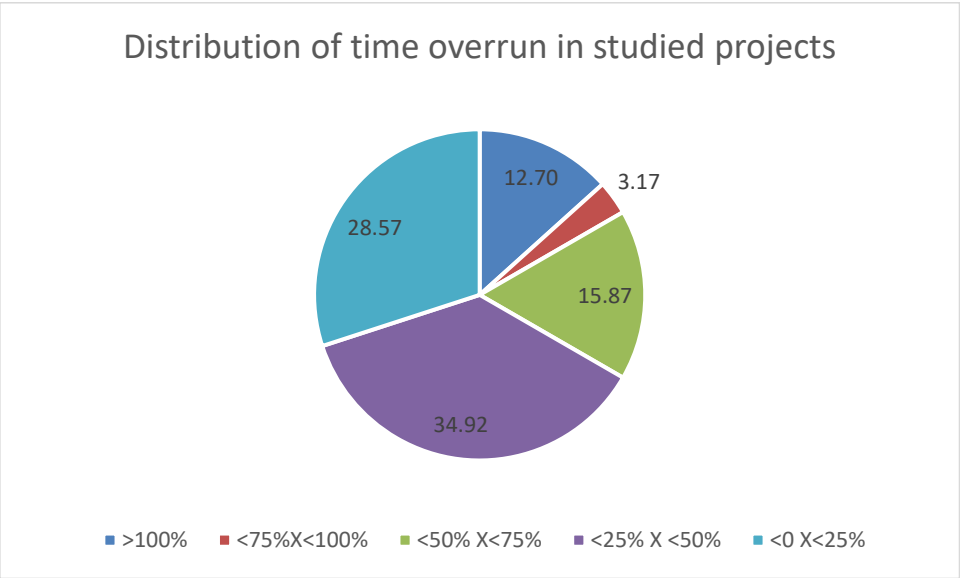

Figure 5: Distribution of time overrun in studied projects

Following the previous phase, the data were organized and modelled by means of the PIM-DEA software (Emrouznejad, Ali; Thanassoulis, Emmanuel;, 2017). As it is explained in methodology chapter. Thereafter, in this step, the relative project management efficiency of the projects was measured using the PIM-DEA software. This measurement was provided as an efficiency score by the software. The obtained efficiency scores are summarized in Table 6 for time management efficiency and Table 7 for cost management efficiency criteria, respectively.

Table 6: Managerial relative efficiency score for time criteria of 51 projects

Project	Efficiency Score	Project	Efficiency Score
01	39.40	32	100
02	100	33	100
03	15.45	34	23.04
04	100	35	100
06	100	36	100
07	100	37	100
08	100	39	100
09	6.83	41	14.55
10	100	42	90.97
12	60.65	43	100
13	36.30	44	100
14	100	46	6.09
15	100	47	100
16	17.13	48	12.93
18	16.13	49	98.39
19	67.12	50	100
20	16.90	51	100
21	100	52	6.54
22	100	53	30.93
23	100	55	100
24	60.37	56	100
25	100	59	12.06
26	15.81	61	14.70
29	100	62	100
30	4.15	63	36.17
31	50.60		

Based on Table 6 , the relative managerial efficiency score in time criteria for 27 out of 51 projects is 100%. That can be explained as follows.

Even with presenting numerous problems and delays, the different management parties included in the running of those projects succeeded in completing the project efficiently. For instance, managers of project 29 efficiently could manage seven adverse causes that affected the project specified time. Encountered causes were the long-time gap between project preparation and real start date of construction, the lack of knowledge in owners and local contractors with the circumstances of the Fédération International des Ingénieurs-Conseils (FIDIC), delays in the approval of some changes by the owner, the unavailability or shortage of required materials in the local market, equipment and manpower shortages, unforeseen events, and a tsunami. Those causes resulted in a time overrun of only %15.

Table 7: Managerial relative efficiency score for cost criteria of 38 projects

Project	Efficiency Score	Project	Efficiency Score
01	96.95	35	100
02	35.54	36	100
04	100	37	5.14
06	100	38	15.26
10	100	39	7.40
14	6.27	40	4.49
15	100	41	4.74
16	1.87	44	54.98
20	11.85	45	23.22
21	13.02	46	4.02
24	7.94	47	21.79
25	51.69	51	21.17
27	100	52	100
28	95.03	54	48.70
29	100	55	3.42
30	47.61	57	100
32	22.95	58	13.96
33	19.90	59	100
34	38.82	63	14.56

As can be seen in Table 6 the relative management performance score in time management is 98.39% for project 49. Project managers of stated project faced with only two encountered adverse causes including unforeseen events and the unavailability or shortage of required materials in the local market. These causes are in common with adverse causes of project 29. This project was reached to end with 33% of time overrun. This completion clarifies that the project managers of above-mentioned project could not capable of overcoming the common causes efficiently in relation with other project which overcame more causes with less amount of delay or time overrun.

In the next step, the attention was on the adverse causes that seriously impacted and declined the managerial efficiency score of the projects. Therefore, projects with less than full efficiency score were taken into consideration. A table was created based on the occurrence frequency of adverse causes in the selected inefficient projects. Then adverse causes were ordered and the ones that having the most serious effect on time criteria, leading to inefficient project management, are shown in Table 8.

Table 8: Frequency of causes impacting time management efficiency in the inefficient projects

	Code of adverse causes															
Project	**33**	**21**	**7**	**43**	**31**	**19**	**14**	**58**	**2**	**52**	**17**	**35**	**18**	**20**	**23**	**63**
01							x	x								
03		x			x				x				x			
09		x				x		x		x	x					x
12						x		x								
13		x	x		x											x
16						x		x	x	x				x		x
18	x			x					x	x		x				
19																
20			x	x	x								x			
24									x	x			x	x		
26	x	x		x									x	x		x
30	x	x	x		x											
31	x				x	x	x				x				x	
34			x	x	x		x				x					
41	x		x				x	x							x	
42							x					x				
46		x	x									x				
48	x	x				x		x			x				x	
49																
52	x	x	x	x		x						x		x	x	
53	x															
59	x	x		x						x						
61				x			x									
Frequency	**10**	**9**	**7**	**7**	**6**	**6**	**6**	**6**	**5**	**5**	**4**	**4**	**4**	**4**	**4**	**4**

According to Table 8 and Table 2, it can be indicated that “delays in mobilization by the contractor”, “project design changes”, “poor project management and supervision” and “severe weather conditions” are the four important frequent causes that critically influence the time management of projects.

Separately, the efficiency of cost management was also studied, and Table 7 summed up the managerial cost efficiency scores for the studied projects. This table plainly

indicates that 11 out of the 38 projects are efficient in terms of cost management criteria. It clarifies that project managers could able to accomplish those 11 projects with efficient cost management even with incidence of adverse causes that impacts the estimated cost. The rest 27 project managers could not completely be successful in managing the cost against causes efficiently in comparing with successful project managers. For instance, the US$ 465 million studied project denoted by project 36 is an efficient project. All parties responsible for the management of this project faced with inaccurate cost estimates in appraisal, changes in the scope of the project, changes in land acquisition prices, and design changes to perform the project with a cost overrun of just 2.2%. In the meantime, project 37 was influenced by three adverse causes which are mutual with project 36. Influence of causes and inefficient cost management directed this project to 75% of cost overrun from $762 million to $1,333 million.

Thereafter, in line with the information in time management efficiency part, the significance of efficient cost management is concluded. However, 27 out of the 38 studied projects are inefficient ones.

Similar to time management efficiency calculation, Table 9 shows the occurrence and total frequency of adverse causes detected in projects with cost management efficiency less than 100% score.

Table 9: Occurrence and total frequency of causes influencing cost management efficiency in inefficient projects

Code* / Project	37	47	53	62	52	20	21	42	2	10	61
01	x										
02	x						x	x		x	
14		x			x				x		
16	x		x		x	x					
20	x									x	
21	x	x				x				x	
24			x	x	x	x	x	x			
25		x							x		
28					x		x	x			
30	x										
32	x										
33		x			x	x		x			
34	x					x		x	x		
37			x	x			x				
38	x	x									x
39	x	x	x	x							
40	x		x	x	x	x	x				x
41	x								x		
44		x									
45	x	x		x							
46	x		x							x	
47	x				x						x
51	x			x							
54	x			x							
55	x	x	x	x				x	x		
58	x	x	x				x				
63		x	x								
Frequency	19	11	9	8	7	6	6	6	5	4	3

Table 2 and above table point out that fluctuations and escalations in the prices of material, equipment, and labor have the most influence on the cost management efficiency score. As the studied projects are international projects, changes in the US dollar exchange rate also influenced the cost management efficiency. Underestimated and inaccurate appraisals and increases in the land acquisition price and compensation were other frequent and influential causes.

A different point that requires more attention is that there are four mutual critical causes in Table 8 and Table 9. Common causes are the “increased quantity of work by additional works” (20), “inaccurate initial project scope” (2), “increases or changes in the scope of the project” (52) and “design changes” (21). These causes frequently occur and influence the management efficiency of both time and cost criteria.

With the aim of study, the importance of the aforementioned 10 frequent cost causes on the cost management efficiency, and influence of earlier defined 20 time adverse causes on time management performance, sensitivity analysis approach was implemented. Through the support of sensitivity analysis, the influence of every single adverse cause on the overall efficiency of the assigned project’s management team was verified. This particular analysis assisted the identification of the degree of deviation in other words, the scale of influence of each cause in terms of consequence on the efficiency of project management of construction projects. The sequential steps followed in this study for identifying the size of influence of each cause on management efficiency are; (1) Removal of each cause as input from the critical causes list one after another, (2) Calculation of the efficiency value of project managers following to execution of step (1), (3) computation of the degree of declines in value from earlier efficiency average with the purpose of determining the level of importance for each cause.

For each project, reduction in management efficiency score related to original one reveals the significance of removed cause in that project management performance. As done by Montoneri et al, extent of change in the new efficiency average of all projects from the primary efficiency average specifies the level of significance for the eliminated adverse cause (Montoneri, Lin, Lee, & Huang, 2012).

Table 10 and Table 11 indicates the outcomes of sensitivity analysis and the deviation in the new efficiency average associated with the original efficiency score average for the time and cost criteria. Based on the results summed up in Table 10, the changes given by eliminating design changes (cause 21), delay in mobilization by contractor (cause 33), and poor project management (cause 7) from the primary average value are larger than for the other inputs. Accordingly, it can be concluded that these causes have a greater influence on the efficiency of the time management of projects.

Table 10: Outcomes of sensitivity analysis and deviations in time criteria

Cause Code	New Efficiency Average	Cause Code	New Efficiency Average
2	67.71	35	67.71
7	52.04	36	67.71
14	57.34	42	58.74
17	67.54	43	61.35
18	67.71	44	62.56
19	67.71	50	66.74
20	65.75	52	67.71
21	24.27	58	63.02
31	67.49	63	63.78
33	42.09	64	66.66
Average of efficiency scores in Table 10: **67.71**			

As it is shown in Table 11, the investigated projects are most sensitive to underestimated and inaccurate appraisals (cause 53), changes in the exchange rate (cause 47), and an increase in the quantity of work (cause 20). According to the results, these causes have a more influence on the cost management performance than other causes. The outcomes attained by the sensitivity analysis using the Performance Improvement Management software are in agreement with the outcomes of Table 6 and Table 7. Likewise, these results approve that the causes studied here not only influence on the final cost and time of projects, but also impacts the efficiency of time and cost management.

Table 11: Outcomes of sensitivity analysis and changes in cost criteria

Cause Code	New Efficiency Average	Cause Code	New Efficiency Average
2	37.96	47	37.07
20	37.35	52	44.77
21	47.64	53	29.66
37	41.63	61	42.56
42	46.42	62	47.17
Average of efficiency scores in Table 11: **47.17**			

6.3 Importance of Time and Cost Management Efficiency

Consciousness about the degree of the relations between time and cost management efficiency is a vital subject. This possibly will assist decision makers and project administrators to carry out preventive actions to lessen the likelihood of time and cost overruns occurrence. Subsequently, in the next part of the existing study, projects that experienced both time and cost overruns were carefully chosen.

According to Table 6 and Table 7, only seven out of the entire thirty projects were successful in managing both the time and cost criteria independently to attain 100% efficiency. Projects 11 and 21 have inefficient administration in relations to time and cost criteria, respectively. Figure 6 and Figure 7 imply probability tree diagrams of the projects in relation to time and cost management efficiency.

Figure 6 simply demonstrates that, in the case of inefficient time management, the probability of inefficient cost management is just about 4 times higher than that of efficient cost management. As a result, time management is much more serious than cost management.

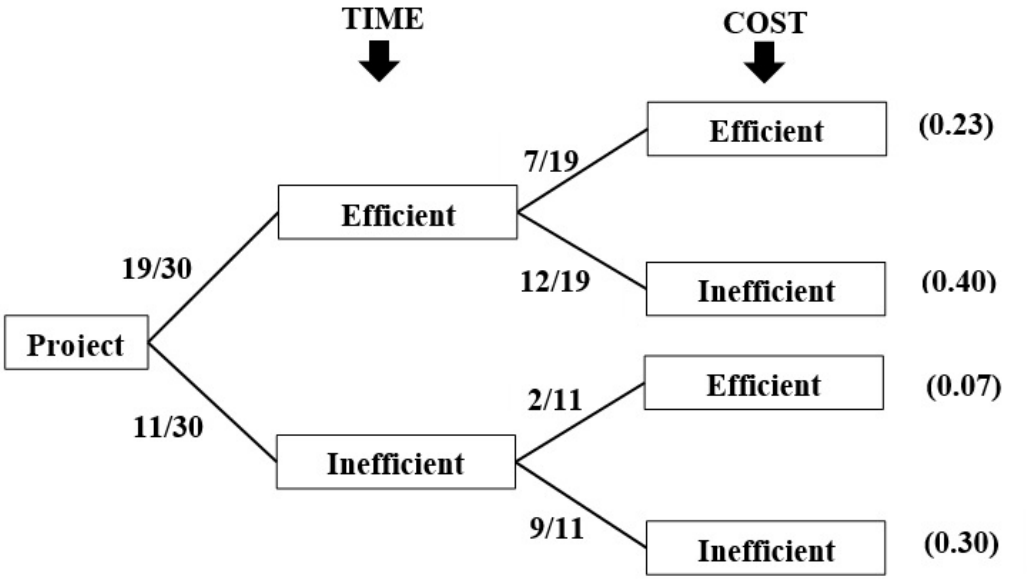

Figure 6: Probability tree diagram of efficiency for time management criteria

Based on Figure 7, it is possible to conclude that the studied projects generally failed in terms of cost management efficiency. Furthermore, efficient cost management is more expected to lead to efficient time management than to inefficient time management.

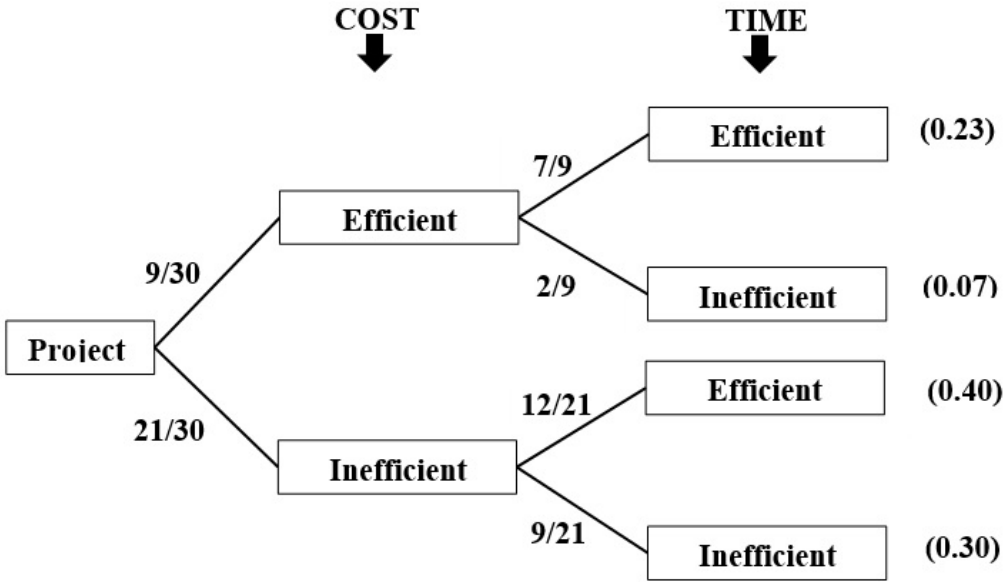

Figure 7: Probability tree diagram of efficiency for cost management criteria

6.4 Impact of Different Elements of Project Management

It is commonly thought that arisen cost and time overrun in the investigated projects are a result of adverse causes that are rooted from other project management features at the same time. Adverse causes 3, 5, 8, 16, 24, 28, 45, 52 and 58 listed in Table 2 have direct relation with Communication Management, Quality Management, Procurement Management, Health and Safety Management, and Scope Management. As a result, it can be resolved that not only time and cost management, but also existence of some other project management features influences the time, and cost management efficiency. In the other hand, time and cost management efficiency is a part of most of other project management features combination.

6.5 More in Depth on Results of Sensitivity Analysis

In this part of study, causes selected for sensitivity analysis were taken. As previously discussed, the results of the sensitivity analysis in this study show in what extent time and cost management efficiency are sensitive to those causes. Thereafter causes were sorted based on their deviations from average of efficiency score indicated as 67.71 for time and 47.17 for cost criteria from highest to lowest respectively. Afterward the causes with no deviation from average were eliminated for both time and cost criteria.

Table 12: Critical Time and Cost Criteria Causes Based on Sensitivity Analysis

Code	Adverse Cause	Affecting Criteria	Rank
21	Design changes	Time	1
33	Delay in mobilization by contractor	Time	2
7	Poor project management, construction management, and supervision	Time	3
14	Slowness of the owner's decision-making process (approval of activities)	Time	4
42	Poor and unforeseen site conditions (location, ground, geological, events, security)	Time & Cost	5 & 8
43	Severe weather problems (heat, cold, snow, rain, cyclone)	Time	6
44	Political issues, changes	Time	7
58	Poor procurement procedure (longer period or procedures in bidding)	Time	8
63	Delay in land acquisition	Time	9
20	Increase in quantity of work (additional works)	Time & Cost	10 & 3
64	Delay in appointment of consultant	Time	11
50	Complicated administrative and governmental procedures (institutional problems)	Time	12
31	Inadequate contractor experience (poor performance of contractor)	Time	13
17	Delay in approval of feasibility study, drawings, and material	Time	14
53	Underestimate and inaccurate appraisal (missing measures, cost adjustment)	Cost	1
47	Change in exchange rate	Cost	2
2	Inaccurate initial project scope	Cost	4
37	Fluctuation and escalation in prices (materials, machinery, labor, equipment)	Cost	5
61	Additional project management, consultancy, and administration costs	Cost	6
52	Increase or change in scope of the project	Cost	7

Remaining causes were selected for the more in depth investigation for every single of the adverse causes to find their main reasons of occurrence, consequences and preventive and corrective actions. The results of this part of investigation are written in Chapter 7.

Chapter 7

ROOTS, CONSEQUENCES, RECOMMENDED PREVENTIVE ACTIONS, AND MITIGATION MEASURES FOR CRITICAL CAUSES

7.1 Introduction

In this chapter, in parallel to the scope and objectives of current research and based on the procedures in the methodology part, preventive and mitigation measures for each of adverse causes in table 12 were developed. Recommendations and solutions presented in this chapter are the result of an in-depth review of a large number of articles, websites and specially interviews with domain experts and the personal experiences of the author in large construction projects. It should be noted that, references at each part to scientific resources or websites additionally indicates that some contents not totally but thoughtfully or ideally used.

7.1.1 Design Changes

It is a frequent adverse cause that lead the construction projects to time and cost overrun. Change in construction industry can be defined as any addition, deletion and modification of the existing construction plans or methods of implementation. This cause generally occurs during construction phase and threatens construction projects with failure in achieving objectives of time and cost criteria.

Design changes may arise due to the following factors which effect of them are ignored in some extent by owners and contractors (Olawale & Sun, 2010), (Prasad, Vasugi, Venkatesan, & Bhat, 2019).

1) Poor use of innovative design software;
2) Design inaccuracies by consultant;
3) Lack of extensive investigation of construction site;
4) Delay in delivering the latest desgin by designers;
5) Construction failure(s) by contractors;
6) Changing Employer's Opinion on Project Usage.
7) Change in laws and regulations;
8) Cost saving.

Poor attention to the design change by practitioners as a high influensive cause on fate of the construction projects have serious consequences. Consequences of design change in construction projects may listed as followings:

1) Delay in delivery of the project on specified time;
2) Budget exceed; Failure in finishing the project with authorized cost;
3) Low profit margin;
4) Suspension of in progress activities;
5) Additional works;
6) Change orders;
7) Reconsideration and modification of scope of the works;
8) Arbitration disputes;
9) Litigation;
10) Contract modification;

11) Revocation of contract.

Based on the results of sensitivity analysis, time of construction projects is most sensitive to design changes cause. Moreover, it was a frequent cause among the adverse causes in studied large projects.

Based on the obtained information from literature through online resources and subsequently conducted interviews with experienced civil engineers and project managers, suggested preventive actions and mitigation measures for design changes can be summarized as followings. In the first part preventive actions might be as:

1) Construction site(s) should sufficiently/extensively inspected in all stages before inception of implementation and responsible higher manager in consultant, design agency or owner should certify and confirm the adequacy of inspections.
2) Project main contractor should be informed in-time by owner or design agency about the probable changes in project's authorized time and cost and the procedures according to the articles of contract and prior to applying changes;
3) Project design stage schedule and dedicated budget have to be sensible, practical and adequate;
4) Proper depiction of owner's demands and considerations;
5) Design changes should be done by authorized people or team with adequate knowledge about the project conditions;
6) Design changes should be notified and signed by project manager or authorized people on behalf of owner/client;
7) All specifications, drawings and specific details should be in scale, legible, plain and easy to read;

8) Design information has to be clear, legible, adequate and understandable in tender documents;
9) Any changes and its subsequent changes must be made to all plan sheets;
10) A market survey for availability of equipment, materials and technology in local market for probable changes should be done by design team prior to any change;
11) Structural designs should be controlled based on new change(s) in dimensions and shapes.
12) Owner/Client should be aware of the consequences of his/her decision on time and cost criteria of the project and reevaluate decision;
13) Enforcement of design build contract.

Prior or during the implementation phase of project, if any design changes occurs, mitigation measures should be undertaken by contractors in order to prevent the projects failing into time and cost overrun. The recommended mitigation measures are as followings:

1) Change construction method to a different one or use advanced technology with lower implementation time and cost.
2) Owner or his/her representative in construction site has to monitor the performance of contractor during design changes for faster implementation;
3) Inaccuracies in plans or specifications during implementation should instantly corrected by design team to compensate the imposed delay or extra created cost;
4) Increase the number of tools, workers and machinery or change their setting up or allocation in construction site;

5) Recuitment of well-experienced construction managers;
6) Avoid suspension of works by continues comunucation and coordination with design team, consultant, client's representative or client.
7) Investigation of the consequences of the ordered changed into the successive activities and quantity of changed activities;
8) Inspection of conformance of the requested changes with contracts and agreements;
9) Revise progress of activities or scheduling;
10) Accelete none affected activities to save time and recover the probable delays;
11) Revise the construction health and safety countermeasures;
12) Adding overtime.

7.1.2 Delay in Mobilization by Contractor

Mobilization is a preliminary phase including all activities that should be done by contractor after appointed by owner/client and before starting the implementation phase of construction. Aforementioned activities consist of moving the contractor's manpower, machinery, material resources to the construction site. Construction of temporary offices for personnel of contractor and client, toilets for staff and workers, and other essential facilities for the contractor's operations at the construction site are also included in mobilization stage.

According to the results of sensitivity analysis, time of construction projects are highly sensitive to delay in mobilization by contractor after design changes cause in the second place. Moreover, it was another frequent cause among the adverse causes in studied large projects.

Delay in mobilization by contractor may arise due to the following reasons:

1) Bureaucracy in tendering method;
2) Change in Government policies;
3) Political interference;
4) Inadequate fund to start the project;
5) Unforeseen site conditions;
6) Change in work scope by client;
7) Mistakes in design;
8) Conflict between project parties;
9) Postponment, suspension or delay in carrying out site survey by contractor;
10) Inadequate, incomplete or inaccurate site survey by contractor;
11) Inadequate number of workers brought to site area by contractor;
12) Inadequate number of requried equipment;
13) Security restrictions on entering to site area for employee's of contractor.

Poor performance of contractor in mobilization stage generally have adverse results on scope and objectives of construction projects. Some of the consequences of it might be listed as followings:

1) Delay on starting the project;
2) Delay in delivery of the project;
3) Cost overrun;
4) Financial loss for contractor;
5) Disputes;
6) Arbitiration;
7) Litigation;
8) Revocation of contract by client;

9) Change in scope of the project.

Mobilization stage should perform quickly by contractor. Client should support the contractor through his/her obligations to help contractor start the project on time. To prevent delay in mobilization, following recommendation might be useful:

1) Owner should make more legislative and operational support available to contractor;
2) Utilizing suitable tools and construction methods;
3) Client should provide advance payments in time;
4) Contractor should follow receiving advance payment before stating mobilization;
5) Construction site should be cleared quickly;
6) Selecting committed and experienced main contractors;
7) An experienced project management on behalf of client can be appointed to follow watch and supervise (in case) the progress of the work;
8) Client should make sure about the financial status of contractor before inception of the work and especially before signing the contract;
9) A check list of required activities should be prepared;
10) Progress of mobilization should be scheduled based on the authorized time;
11) Mobilization activities should be followed and verified by contractor in daily basis;
12) All requirement for construction site including land purchases and utility permits should be obtained by client;
13) Prediction and existence of mechanisms to overcome this issue in planning stage;

14) A national code for mobilization should be introduced.

In order to mitigate the effects of delay in mobilization, the following recommendations are given:

1) Decreasing duration of construction critical activities;
2) Encouragements of the contractor to finish entire project in time;
3) Boost the productivity of workers and equipment by working overtime, by giving incentives to workers and operators;
4) Using more much modern and productive equipment to save time;
5) Increase the number of workers if the site limitations and conditions allows;
6) Make availability of contractor key personnel in site area compulsory from the inception of the construction project.

7.1.3 Poor Project Management, Construction Management, and Supervision

In order to attain a good project delivery, presence of extra construction management and supervision is necessary. Generally, a successful project is a product of skilled, trained and qualified project managers. Derivation from successful finalization of construction projects might be rooted in following reasons:

1) Lack of proper training and experience for PMs in the area;
2) Hiring or employment of inexperienced,untrained, unskilled and unqualified project manager;
3) Lack or poor communication and coordination in between project parties;
4) Trust instead of continues inspection;
5) Missunderstanding of the owners required work;
6) Lack of poor experience of subordinates;
7) Shortage of skilled labor and engineeris;

8) Ambiguity in executive plans and specofications;
9) Financial difficulties of owner;
10) Financial difficulties of contractor;
11) Lack or Shortage of required materials in local market;
12) Delay in material delivery to project's sites;
13) Frequent change orders by owner.

Ineffective project management and supervision has numerous defects on construction projects. The most critical adverse effects of poor supervision and construction management can be listed as followings:

1) Unsucess on achieving project goals and objectives;
2) Project will not reach to delivery within stipulated time;
3) Specified cost in contract would be increased;
4) Damge to the project output and stakeholders;
5) Poor quality of works done;
6) Reworks;
7) Low margin of profit for contractors;
8) Health and safety issues, Accidents;
9) Decrease the productivity of workers and equipment;
10) Increase/Additional usage of resources;
11) Ineffective distribution of staff, workers, plants and facilities;
12) Poor scheduling of ongoing and future activies;
13) Unsuitable construction approaches and errors during construction phase.

To prevent occurrence of the aforementioned cause, the subsequent approaches are recommended:

1) Owner should make more legislative and operational support available to contractor;
2) Organized and wide-ranging project planning;
3) Define appropriate approaches according to resources availability;
4) Selecting suitable and executivable construction approach and methodologies;
5) Verification and confirmation of the accurateness of the contractor's methodologies and plan for construction activities by owner or his/her legal representative;
6) Progress of the activities should be inspected, observed and reviewd by owner continuesly or in a periodic manner as a control mechanism;
7) Generating a table of activities and sequences for implementation by contractor;
8) Determining the deviation of the existing phase/date from the pre-planned phase of the project in a weekly/monthly manner (milestones);
9) Monthly up to date risk pridictions according to the latest conditions during project implementation;
10) Evaluation of each project phase before starting new phase(s);
11) Periodic project management training programs for project managers;
12) Force project managers to attend in training programs reguarly by governments to improve the project management knowledge of them;
13) Frequent and preiodic project meetings and co-ordinations with involved parties;
14) Proper use of the past experiences;
15) Qualification and commitment of contractors should strictly ensuered by owner/client;

16) Skill and experiences of contractor's project manager should be an article of the contracts;
17) Employ skilled subcontractors and work with experienced suppliers;
18) Using experience of subcontractors and suppliers by brainstorming on required issues;
19) Improve construction management of activities by sufficient control over actions and activities of subcontractors;
20) Implementation of proper safety mesures in construction site;
21) Adding reward and punishment articles to the contract of involved parties;
22) Improve transparency and enforcement by client in requirments;
23) Use financial incentives for project managers in case of successful delivery of projects.

Poor project management has critical effects on projects. These effects are serious and in some cases might be irrecoverable. Therefore, mitigation of effects are vital. To mitigate the effects of poor construction management in projects, followings are highly recommended:

1) Increase the number of project status meetings and coordinations with other project parties;
2) Invesigate and find simillar past experiences and use them;
3) Change or applying much more appropriate construction technology and methods;
4) Change the project managers or project management team;
5) Change the scheduling and planned activities order;
6) Implementation of corrective arrangements;

7.1.4 Slowness of the Owner's Decision-making Process (Approval of Activities)

Owners and their appointed consultants or project managers in construction projects normally make critical decisions during project implementation. These decisions are normally having high degree of importance and play a significant role in success or failure on attaining scope and objectives of construction projects. Therefore, a fast and in-time decision making process is crucially important. Slowness in decision making process may have rooted in:

1) Poor coordination between project parties;
2) Poor experience of owner's project manager;
3) Poor attention of owner to consequences of slow response to the arisen problems that needs timely action;
4) Long time waiting period for gathering accurate and adequate information about the arisen problem;
5) Long holiday period or none working days;
6) Absence of key decision makers;
7) Disputes with contractor;
8) None-existence of clauses in contract regarding to maximum timeframe for owner decision making process;
9) Administrative bureaucracy;
10) Poor communication in between owner and other involved parties;
11) Financial considerations of owner;
12) Poor planning and design;
13) Occurrence of unpredicted events;

The following consequences may arise by slow decision making process of owner:

1) Delay in timely delivery of project;
2) Financial loss for owner;
3) Partly or full Suspension of the work;
4) Unnecessary activities by other parties;
5) Short and long term impacts;
6) Change in scheduling of construction activities;
7) Damage to the facilities;
8) Complain and claims by contractor;
9) Financial loss of contractor;
10) Litigation in the judiciary;
11) Affection of quality of work;
12) Safety issues may come across.

In order to prevent the above cause and make the process timely; following instructions are recommended:

1) Awareness of clients about the consequences of slow decision making process;
2) Impacts and consequences of late decision making should be officially notified by contractor;
3) Indication of a deadline for decision making time in contract;
4) Hire experienced consultant to help in process of decision makings;
5) Accelerate the decision making processes through frequent by person meetings between clients and other involved parties representatives;
6) Give the decision authority to experts and experienced project managers;

7) Conduct a comprehensive survey to well identify the problem that needs decisions to rectify;
8) Providing adequate and accurate information about arisen problem;
9) Authorize overtime payments for decision makers by owner if there is any;
10) Decision makers should have adequate knowledge about construction methods;
11) Decision makers should have sufficient information about available resources;
12) Daily reporting of the latest statues of the in progress activities and difficulties;
13) Payments to decision makers/consultant should be done on time;
14) Decision making teams should be consisting of engineers with different expertise in construction management;
15) Setting up a networking system on internet with all involved parties;
16) Using knowledge management techniques like setting up a documentation system for the times that there is a need for decision making and past experiences and their solutions may work;
17) Non-specified details should be asked earlier by contractor;
18) Including time contingency in contract;
19) Providing comprehensive design in the right time.

In the case of failure in fast decision making process by owner, the involved party which mostly affected is contractor. This process should be done faster in order to decrease the encountered damages to contractor and to the owner accordingly. According to the literature and interview with experts, following mitigation measures are suggested:

1) Refer to old documents to find the most suitable solution for similar or same problems;

2) Contact with other project managers or experts in the region to learn about their solutions on same problems;
3) Accelerate speed of in progress activities to make up for the lost time;
4) Preparing a claim document by contractor for the lost time and expenses based on contract,
5) Dismissal of inexperienced decision makers;
6) Start the work on different or independent phases of construction site;
7) Asking liquidated damage by contractor.

7.1.5 Poor and Unforeseen Site Conditions (Location, Ground, Geological, Events, Security)

Construction projects are naturally complex. This complexity requires accurate preparation, scheduling and delivery methods. Often construction companies faces adverse site condition after starting of construction phase. It mostly occurs when contractor companies find the ground condition different from their prior visits of the site, expected conditions, studied, designed and planned by owner or consultants. In some cases, the location of the construction site is also an adverse factor. Events and security issues are also classified as an unforeseen condition. Poor and unforeseen site conditions might be a result of following reasons:

1) Geographical location of construction project;
2) Poor weather, environment and climate;
3) Inaccurate and inadequate site inspection by construction involved parties;
4) Poor allocation of resources for site investigation by client;
5) Inexperienced site inspectors or incompetent engineers;
6) Different and undesirable soil types and layers in the site location;
7) Underground piece of rocks;

8) Poor prepare of the construction site;
9) High ground water level;
10) Pipes and utility lines;
11) Workers strike.

Resulting effects of poor site condition is different for each construction project. Consequences of this cause may be listed as followings:

1) Disputes between construction involved parties;
2) Exposing of the construction engineers and workers to health and safety issues including accidents and injuries;
3) Delay in timely completion of project;
4) Extra incurred costs;
5) Additional works;
6) Additional materials;
7) Reduction of contractor's profit;
8) Decrease in the productivity of equipment;
9) Decrease the productivity of engineers and workers;
10) Inevitable destruction or damage to constructed building;
11) Increasing the hazards;
12) Design changes;
13) Change orders;
14) Contract modification;
15) Substantial liability for contractor;
16) Claims by contractor;
17) Abandonment the contract by contractor;

18) Suspension of work.

In order to prevent the adverse effects of poor site condition cause, the subsequent preventive actions are recommended:

1) Fixed price contracts allocates and transfer the risk of additional costs to contractor;
2) Double check the availability of unforeseen condition contract clauses before signing for acts against unforeseen conditions;
3) Adding a clear clause to contract about the allocation or distributing the risk on owner or contractor while an unforeseen condition encountered;
4) Adding a clear clause for the arisen delay in due to unforeseen conditions;
5) Limiting the obligations of parties in contract to only predicted, investigated, seen, and visible conditions;
6) Set a certain contingency cost for unforeseen conditions in contract;
7) Performing comprehensive and adequate soil and site investigation by an experienced engineer(s) prior starting tender process by client;
8) Performing full site survey by contractor before submitting tender documents;
9) Well prepare the construction site before starting the project;
10) Inquiry from governmental departments about the existence of utility lines including gas, water and telephone lines under the site area;
11) Develop detailed procedure to allowance of issuing change orders;
12) Having an alternative plan by adopting different methodologies;
13) Payment to the workers should be done timely;
14) Site condition should be regularly checked for health and safety precautions;

After facing unforeseen conditions during construction phase, mitigation measures should be taken mainly by contractor of the project. Those measures should help contractor in making up the gone time and extra cost. Recommended mitigation measures are listed as followings:

1) Notifying client or general contractor;
2) Notifying design team and asking for further information depend of the type of contract;
3) Meet the owner to find acceptable solutions or methodologies for arisen problem;
4) Request acceptance of client for changing the construction methodology;
5) Asking owner for granting time extension and allocating cost contingency;
6) Meeting and negotiate with the client at the earliest opportunity and attempt to get the owner involved to resolve and cover the arisen problem;
7) Refer to documented site investigation records of the location that unanticipated problem encountered;
8) Potential and magnitude of impact should be studied accurately;
9) Preparing documents to start claim procedure by contractor if negotiations with client failed.

7.1.6 Severe Weather Problems (Heat, Cold, Snow, Rain, Cyclone)

Sever weather problems are one of the most frequent adverse causes in construction industry. Moreover, project planning and design are mostly under influence of the local weather and geography. Latitude, altitude, topographical state of location of project is an important criteria. Nowadays, due to the climate changes, adverse weather conditions are more likely, risky and less forecastable. Severe weather problem in construction includes heat, cold, snowy, rainy and cyclonic conditions. Therefore, it's

vital for construction companies to be well prepared by developing strategies against this problem. Severe weather problems that may affect the implementation phase of construction projects might be a consequence of different natural disasters and evaluations as followings (Jordan Foster Construction, 2018):

1) Thunderstorms;
2) Cyclones;
3) Tornados;
4) Seasonal rain;
5) Damaging winds;
6) Hail;
7) Heavy showers;
8) Hurricanes;
9) Floods;
10) Droughts;
11) Inaccurate and inefficient site location analysis.

Severe weather conditions affecting the implementation of construction projects. Consequences of this cause varies depend on the type and magnitude of the arisen condition. Some direct and indirect results of exposing to this cause might be as followings:

1) Cost overrun;
2) Time overrun;
3) Poor productivity of labors;
4) Poor productivity of equipment;
5) Wet, moldy, contaminated and mixed materials (unprotected);

6) Saturated surfaces in earth moving activities;
7) Frozen materials;
8) Delay in delivery of materials;
9) Damage to the construction equipment;
10) Shortage of required materials;
11) Shortage of labor;
12) Increase the cost of daily workers;
13) Additional material purchase in case of loss of materials;
14) Hazards and health and safety issues including accidents and injuries of working staff;
15) Disorganization of the construction site;
16) Concrete is affected by excessive heat;
17) Masonry work might be affected by excessive heat;
18) Flooding of construction site;
19) Disruption in movement of materials with cranes;
20) Destruction of structures;
21) Damage or destruction of constructed structures;
22) Stoppage of the work;
23) Collapse of excavations;
24) Blocking the access roads to construction site;
25) Sweeping of materials and equipment by flood;
26) Blowdown of temporary structures and materials by wind;
27) Cracks of concrete structures;
28) Accidents due to overbalancing the cranes in windy condition;

As indicated in the above section, severe weather conditions have a wide range of affects over construction projects. Therefore, applying preventive actions against this common problem is quite important. Identified preventive actions are listed as below for different types of natural disasters.

1) Establishment of a good insurance contract against the damages that are a result of adverse weather and natural events;
2) Adding a clear clause to the contract about severe weather conditions;
3) Check the annual metrological data and wind exposure at the construction area or weather pattern during the bid or tender stage;
4) Check the background of the unexpected natural events at the projected area before starting of implementation;
5) Determine the right time to start construction activities based on the historical and up to date weather predictions;
6) Different and alternative strategies should be developed for extreme conditions;
7) Considering time, cost and difficulties in transporting construction materials to project site area due to adverse weather conditions;
8) Train the workers to work in adverse conditions through safety programs;
9) Ensure tools and equipment to work safely in adverse weather condition is available;
10) Transport the required materials to site area prior to start of severe weather condition;
11) Availability of an adequate water pump system to drainage and prevent flooding due to heavy rain;

12) Reschedule implementation of the activities that affecting from rainy condition. (e.g. Earth works and concreating);
13) Cement/water ratio should be modified based on the moist and heat conditions;
14) Reschedule implementation of the activities that affecting from windy condition. (e.g. Lifting materials and working on scaffoldings);
15) Bracing the necessary construction components like brickwork walls and scaffoldings at windy conditions;
16) Avoid from working at the height during windy days;
17) Materials should be covered and stored properly in windy, rainy, freezing and heat conditions;
18) Construction equipment should be moved into safe covered area;
19) Unfinished construction activities should be covered and protected;
20) Scaffoldings should be covered by protective sheeting to make walking area less slippery;
21) Specific types of materials for heat and cold conditions should be used (e.g. cement);
22) Large fans might be useful to prevent the effects of heat on workers;
23) Heaters and fire may be useful to prevent the effects of cold and freezing conditions;
24) Two different temporary roads to site area in order to prevent construction equipment to be bogged or skidding;
25) Additional time in schedule should be seen to make up the arisen delay due to adverse weather condition;
26) Availability of power generators in site area;
27) Prepare flood barriers in case of heavy rains as a protection measure;

28) Change the regular working times in case of heat and cold;
29) Using precast construction members (e.g. Precast concrete beams)
30) Stop the concrete casting activity during heavy rain;
31) Any casted concrete during the heavy rain should be covered and protected;
32) Implementing the work on a front that is not affected by severe weather condition.

In some cases, despite of all preventive actions, adverse weather conditions may damage the constructed buildings, access roads, facilities, workers and equipment. After occurrence of any type of different weather conditions an assessment of arisen damages should be accurately done. Based on the above mentioned consequences and aforementioned preventive actions, following mitigation measures to minimize the caused damages are advised.

1) Use water pumps on site to drainage heavy rain waters immediately;
2) Use power generators to provide electricity for tower cranes and concrete batching plants;
3) Clean up the site area form mud, silt, snow, flood, and construction materials;
4) Recheck stability of unstable structures (e.g. Scaffoldings);
5) Power lines should be controlled for being energized and preventing electric shock;
6) Notify insurance company to evaluate and report the damages and receive compensation;
7) Redesign the damaged structures;
8) Increase the working time or overtime;
9) Increase the productivity of equipment;

10) Increase the productivity of workers;
11) Reschedule the activities based on the arisen damages and overdue tasks;
12) Discuss with client about arisen time and cost overrun due to severe weather condition;
13) Modifying the working times in summer and stop the work in heat times;
14) Removing accumulated snow and ice from working area and roofs as soon as possible.

7.1.7 Political Issues, Changes in the Government and Policies

Politics, change in the government's policies, change in arrangement of political parties in power mostly and significantly affecting the construction projects. In current study it is also confirmed by sensitivity analysis and this cause was ranked as 7th critical cause that impacting time criteria of international construction projects. The aforementioned cause generally is a result of: (Chang, Deng, Hwang, & Zhao, 2018)

1) Wars;
2) Civil wars;
3) Regional conflicts;
4) Riots;
5) Factional competitions and conflicts;
6) Change in type of government or regime changes;
7) Change in the party in power;
8) Revolution.

This cause affects the construction projects and followings consequences might be a result of occurrence of this cause:

1) Corruption;

2) Change in laws;
3) Change in exchange rates;
4) Inflation;
5) Change the price of materials due to inflation;
6) Monopoly of construction materials;
7) Shortage or lack of required construction materials in the market;
8) Change the price of construction equipment due to inflation;
9) Change the price of fuel due to inflation;
10) Change the total cost of project due to inflation;
11) Suspension of the work;
12) Increase the cost of the project due to suspension of work;
13) Late completion and delivery of the project;
14) Abandonment or termination of contract by government;
15) Claims by contractor;
16) Increase the rate of disputes among construction parties;
17) Social problems in construction site;
18) Adverse effect on moral of workers;
19) Labors personal conflict;
20) Late payment of bills;
21) Bureaucracy;
22) Unemployment;
23) Law profit margin;
24) Security issues for staff and workers;
25) Government instability;
26) Delay in approval processes;

27) Delay in payments by government.

It is important to have an in depth understanding of political risk as an adverse cause. In order to be successful in management of effects of political issues on construction projects the following preventive actions are recommended:

1) Avoid undertaking a construction project in unsecure regions and or the countries with uncertain political conditions;
2) Undertake the construction projects far from the conflict area;
3) Consider consequences of political issues that may be occurred before starting the project;
4) Start the project after resolving the political issues and instability;
5) Insurance against political risks;
6) Implementation of construction projects with short length of time;
7) Joint venture contracts;
8) Follow approval procedures;
9) Getting necessary governmental guarantees;
10) Fixed price contracts might be useful for owners;
11) Modify or adding a clause to contract to formulate the new prices due to inflation;
12) Modify or adding a clause to contract to compensate the delay and cost overrun due to in case of suspension of the works;
13) Submission of a change order by contractor;
14) Pre-purchase all materials and required equipment;
15) Signing the contract in foreign currency;

16) Employ experienced project managers and workers that worked under similar conditions before.

As a result of paying poor attention to follow the important tips and preventive actions; political issues may lead the project to failure. Therefore, as a secondary action, mitigation measures should be taken. Depend on the effect of the political issues cause on the construction project the following mitigation measures should be taken in order to make up the rate of failure of project:

1) Legal actions to obtain compensation in accordance with the contract;
2) Improve the management of the project through adding much experienced members to the team;
3) Rescheduling the tasks;
4) Revise the plans and objectives of the project;
5) Suspension of the work to save money and security of staff;
6) Termination the contract;
7) Claim monetary damages from the contracting insurance company;
8) Modifying the type of used materials into available ones in the market in coordination and agreement of client;
9) Follow the new scheduling strictly;
10) In case of international projects, employ local workers and engineers and send foreigners to other projects;
11) Increase the productivity to make up the gone time;
12) Ensure about the availability of financial resources and client's financial status;
13) Employ an experienced consultant;
14) Increase communication channels with client.

7.1.8 Delay in Land Acquisition

One of the most important adverse causes in road construction projects is land acquisition and resettlement program. Due to increase on the population of the world and creation of new villages and cities, need for construction of new intercity and access roads, highways, railroads, airports, bridges and other infrastructure projects is vital and inevitable. Land acquisition basically occurs while parcels of lands geographically located on the project implementation path.

Generally, the subject of the project is publicly announced before the start of the project. As soon as landowners around the project area aware of project pattern and pathing direction, land prices will rise significantly. Even some of the land owners refuse to sell their lands against monetary or non-monetary compensations that set by the government compulsorily in accordance with the laws. This issue leads the road construction projects to more cost and mainly high amount of time delay due to disputes. The following reasons are probable reason of delay in compulsory land acquisitions by governments (Syagga & Olima, 1996), (Babatunde, Adeniyi, & Awodele, 2017):

1) Absence of owners of lands and properties;
2) Owners willingness to sell their lands and properties;
3) Government willingness for fast land acquisition;
4) Lack or poor of financial resources;
5) Lack of poor experience on land acquisition and resettlement programs;
6) Wrong information about the lands and properties;
7) Complicated administrative and governmental procedures;
8) Religious disputes;

9) Incompetence decision makers;
10) Corruption;
11) Legal disputes;
12) Litigation;
13) Compensation disputes;
14) Missing information about existence of land and properties;
15) Increase the cost of acquisition and resettlement plans;
16) Lack or poor readiness of resettlement area for displaced people.

Land acquisition has some direct and indirect negative effects. These effects are greater when large parcels of land are acquired. Some consequences of land acquisition are listed as below:

1) Late completion of project;
2) Cost overrun;
3) Community pressure and resistance against government by the affected public;
4) Decrease of agricultural products;
5) Agricultural lands will be lost;
6) Unemployment of those who have lost their agricultural land;
7) Changes in the livelihoods of people;
8) Relocation of property owners;
9) Displacement of property owners;
10) Changes in earnings levels;
11) Change in type of land ownership;
12) Claim for compensation;
13) Court cases;

To prevent delay in land acquisition procedure, some preventive actions should be taken by governments or acquiring authorities. The following actions are suggested to prevent delay and time overrun.

1) Land acquisition should be avoided or reduced as much as possible;
2) Before carrying out of bidding stage, a detailed and comprehensive investigation about the number of lands and property owners that are within the project area should be performed;
3) Adequate time should be assigned for the land survey investigation, design phase and land acquisition part;
4) Impacts of the cause should be comprehensively considered during design phase;
5) Past experiences should be applied (If any);
6) Land acquisition should be done prior to start of civil works;
7) Clear, efficient and organized land acquisition should be performed;
8) Financial resources should be adequately prepared and funded in advance to pay as compensation to affected people;
9) Technical and legal assistance should be provided to agency in charge of land acquisition;
10) Land swap offers by government to land owners;
11) Comprehensive contracts between government and land and property owners;
12) Shifting the utility lines; demolishing of structures and clearing the lands from trees should be done prior to start of physical implementation phase;
13) In case of resettlement agreements for affected people, resettlement area should be prepared timely;
14) Designs and plans of project should be flexible for any modification;

15) Location of important facilities like restaurants and gas stations should be placed after performing of land acquisition;
16) Acceptance of land or property owners for selling their land and property should be taken before start of project civil works;
17) The traded land must be evacuated and handover by the seller at the specified time in contract/agreement of sell;
18) Land acquisition should be performed in shortest possible time;
19) Employment of experienced and committed dealers to deal and purchase lands fast and fairly;
20) Increase the amount of building permit prices to make the keeping of land more costly to land owners;
21) Make the land owners a share holder of project benefits;
22) Avoid crossing and construct the project on agricultural lands or the lands that have owners as much as possible;
23) Perform the road construction on national lands as much as possible;
24) Long term lease or rent agreement with land owners by including special options and conditions;
25) Compensation rates should be clear and lawful;
26) Paying compensations should be based on the type of the land (e.g. Dry, irrigation, residential);
27) Paying compensations should be calculated based on average annual revenue of the land before acquisition.

In some projects circumstances does not go according to anticipated plans for land acquisitions. Generally, delay in land acquisition occurs when all lands has not been

bought together. Delays happens while remaining land occupiers tend to sell their land in higher prices than before. In some cases, land owners try to sell their property to the rate of the day by delaying the sales as much as possible for them. To mitigate the effects of these types of problem on cost and mainly time of project delivery the following mitigation measures are suggested:

1) Design change;
2) Adding new scope and objectives to the plan and increase the revenue of project;
3) Change the direction or location of the project to another path or area that land acquisition prices are minimized;
4) Change the direction or location of the project to another path or area that land owners willing to sell their lands in specified time;
5) Starting a court case by client (e.g. Government);
6) Acceleration of implementation of remaining parts;
7) Acceleration by putting the critical path on other parts of the project;
8) Develop a follow-up plan and periodic tracking of land acquisition tasks.

7.1.9 Increase in Quantity of Work (Additional Works)

Following the DEA analysis, additional works was ranked as the 9th critical cause that mainly affects the time of project. The activities and tasks that are not written and required in body of contract is additional work. In some cases, due to new wishes of client the quantity of to do tasks will be increased. Similarly, any compulsory encountered changes in design and specifications resulting increase the amount of required works is defined additional works. Reworks to cover and repair the shortcomings and mistakes can also categorize as a type of additional work. It should be noted that the type of additional works should fall within the expertise of contractor.

In brief additional works is one of the most regular adverse causes in construction industry resulting time and cost overrun. The most important leading reasons for occurrence of this cause are as followings: (Assylkhanov, 2013), (Scherer, 2014)

1) Client's additional new wishes and requests;
2) Defective or poor construction plan and specifications;
3) Missing details in construction plans;
4) Modification of decisions in line for better ideas to be applied;
5) Modification or change of decisions in line for weather or environment change;
6) Design changes;
7) Increase in total allocated cost;
8) Not identified, not accurate and missing specification and/ or plans in contract;
9) Poor quality of implemented works;
10) Unnecessary and too much plan changes;
11) Poor performance of contractor;
12) Unskilled workers and staff of contractor;
13) Poor management of resources;
14) Extra and unnecessary usage of materials, equipment and workforce in terms of rework;
15) Modification of the contract;
16) New decision making process, approval and permits for new tasks by client.

Generally, an increase in amount of works has adverse effects on the final evaluation for success of the construction projects. If contractor does not receive any respond in specified legal deadline at contract documents and also does not reach to an agreement the following consequences will be occurred:

1) Delay due to waiting for client respond and giving necessary information;
2) Delay due to uncalculated and unplanned tasks;
3) Delay in commissioning the project;
4) Project total budget exceed in compare with appraisal;
5) Reduction or poor quality of work;
6) Profit loss or minimization for contractor;
7) Reduction or shortage of number of workers in different construction zones;
8) Loss of productivity due to tiredness and fatigue of workers;
9) Accidents and injuries due to unplanned health and safety programs in site;
10) Increase in the amount of required equipment;
11) Increase in the amount of required workers and staff;
12) Increase in the amount of required materials;
13) Disputes;
14) Halting the work by contractor;
15) Claims for compensation by contractor.

According to the results of interview with experts and based on their experiences a list of preventive actions against this cause was prepared. In order to prevent late delivery of construction projects due to additional works, the followings preventive actions were listed and recommended:

1) Adding a clear clause about the probable additional works and direct instructions about occurrence of any change in time and cost criteria;
2) Remind and increase awareness of client about the consequences of any additional activity and tasks;
3) Comprehensive survey on the projected construction area;

4) Accurate plans and specifications in contract documents;
5) Control the contract documents before awarding the project for any missing or inaccurate information;
6) Carry on monitoring and control of ongoing tasks on a regular basis;
7) Employment of experienced project managers, engineers and workers;
8) Establishment of additional work policy by contractor.

Increase the quantity of works is an unpredictable issue. Due to difficulty and complexity of construction projects, at any moment during construction phase, the possibility of doing extra work is inevitable. There might be significant time and cost overrun at the end of project unless proper mitigation measures taken. Some mitigation measures regarding to increase in the amount of works are suggested as followings:

1) Assess the effect of the additional works on cost and time of project;
2) Read the contract to follow agreed subjects, legal actions or the conditions to perform claim;
3) Contractor should immediately report to the client in writing about the need for additional work;
4) Establishment of additional work policy by contractor;
5) Employment or hiring more experienced and qualified project managers, engineers and workers if the cause arose due to current employees;
6) Hire day laborer to avoid prolonged working hours;
7) Price survey for new required materials and find the cheapest with required quality in specifications;
8) New additions should be constructed with minimum time and cost;
9) Increase the working hours or working on holidays;

10) Revised and enhanced time schedule and management;
11) Revised and enhanced cost management;
12) Use the lessons learned from previous projects;
13) Manage workforce dispersal after arisen additional works;
14) Analyze the bottlenecks and finding solutions to rectify them without significant time and cost overrun;
15) Subjects of additional works should be added as an additional agreement to main contract for additional authorized time and cost;
16) Halting the work if there is no risk of destruction or structural damage and waiting for client's decision;
17) Claim compensation for consequential losses;
18) Potential and risk of safety problems related to additional works should be predicted to avoid extra delay due to accidents.

7.1.10 Delay in Appointment of Consultant

Consultants are experts that generally employed by the owner of the construction project to facilitate effective performing of construction project tasks. Tasks might consist of outlining the project, cost estimating, preparing and organizing tender documents, assessments of bids; selecting contractors based on their qualifications; preliminary and detailed planning and design, inspecting the contractor's performance, quality control of constructed structures and coordination between client and contractor. In a construction project there might be different consultant companies for different activities. For instance, there might be procurement consultants as well as construction supervision consultant. Qualified Consultant Company should be recruited timely. Any deferral in recruitment of consultant may lead the construction

project to postponement of delivery date. Occurrence of this cause might be due to the following reasons: (Jones, 2018), (Department of Education and Training, 2019)

1) Failure to attract and appointment of qualified consultant due to contract defects;
2) Missing / Unavailability of selected consultant after a long procedure and decision period by client;
3) Financial issues of client;
4) Incorrect procurement decisions by client due to unexperienced in-house staff;
5) Bid evaluation and selection procedural issues;
6) Bureaucratic procedures;
7) Lack, weak or not availability of qualified consultants in the area;
8) Insecure conditions for international consultants;
9) Long and complex tender procedures for selecting a competent consultant;
10) Long negotiation period for selecting consultant by client decision makers;
11) Withdrawal of the selected consultant.

According to the type of consultancy services that a client requires, a contract will be signed in between those parties. Any delay on recruitment of consultant for construction projects has some adverse effects on construction projects. Some consequences of delay on appointment of consultant by owner are as followings:

1) Delay in submitting feasibility studies;
2) Delay in start of design phase;
3) Delay in submitting of drawings;
4) Delay in preparing of specifications;
5) Delays in procurement procedures;

6) Delay in the start of bidding for the main works contract;
7) Delay in making decisions about favored contractor;
8) Delay in start date of project;
9) Inconsistency with the physical progress of the project;
10) Delay in implementation of project;
11) Delay in commissioning of project;
12) Claim by the contractor for change in prices due to delay.

With the aim of preventing delays due to being late in recruitment of consultant in construction projects the following preventive actions might be suitable.

1) Identify the proper appointment requirements;
2) Consultant recruitment procedure should be simple and done timely;
3) Consultant assessment and recruitment period should be reduced to limited or a short time;
4) Applicants should be informed about the processes periodically (e.g. Daily, weekly);
5) New consultant assessment, scoring and selection methods should be performed;
6) Selection of consultant applicant should be fair, equitable, reasonable and logical in order to prevent any complain by other applicants;
7) Selection and appointment process should be transparent;
8) Fast paper works and institutional processes;
9) Selected consultant should be informed by issuing offer letter in the shortest time that is possible;
10) Negotiations with selected consultants should be done in short time;

11) If appointed consultant terminate the contract, another consultant should be replaced as soon as possible;
12) Advance payment to appointed consultant should be done immediately after contract is signed;
13) Authority for decisions on procurement process should be given to qualified consultant by client;
14) If there is a security issue in the region, halt the project up to the time that project area is safe and ready for implementation phase.

In case of delay on appointing qualified consultant, clients should start doing corrective actions. Corrective actions may help to make up the gone time. Some corrective actions might be as followings:

1) Using in-house capabilities of client for a short period to cover absence of consultant;
2) Using the contractor's in-house capabilities;
3) Accelerate construction activities;
4) Eliminate the unnecessary tasks and activities;
5) Reschedule the time frame of the project;
6) Compress the duration of critical activities as much as possible;
7) Independent tasks should be done in parallel direction to save time.

7.1.11 Complicated Administrative and Governmental Procedures

An adequate amount of bureaucracy is essential for public organizations to protect their processes and procedures. However, when administrative procedures excessively become complicated, bureaucracy as an adverse institutional problem will be emerged and acts as an obstacle. Governments and public institutes have long been considered

to be the cradle of complicated administrative procedures or in the better word having higher degree of bureaucracy. Bureaucracy comprises of plenty of problematic instructions and steps for simple subjects and even incomplete additional procedures for complicated ones. In bureaucracy, additional regulations and excessive formality, rather than improving performance, hinder efficiency, speed of the work and the way it works. Generally, this inefficiency as an adverse cause lead the construction projects to delays. Followings are the probable roots of the bureaucracy:

1) Unclear rules and regulations;
2) Organizational Structure;
3) Different layers and chain of commands;
4) Public sector's management and institutional weakness;
5) Long-lasting administrative systems of government organizations and ministries;
6) Inadequate skills of associated authority;
7) Low degree of risk taking by associated authority;
8) Improper management;
9) Low innovation capabilities of organization staff;
10) Lack of deterrent laws and regulations and effective control systems;
11) Lack of transparency in dealing with cases of corruption;
12) Lack of sufficient revenues for public employees;
13) Increasing poverty in different sectors society;
14) Corruption;
15) Excessive formality;
16) Unnecessary paperwork;
17) Prolonged complex procurement processes;

Paperwork, protracted institutional procedures lead the construction projects to experience different types of delay. The most important consequences of complicated administrative and governmental procedures are:

1) Delay in procurement processes;
2) Delay in approval processes;
3) Delay in awarding contract;
4) Delay in delivery of the project;
5) Delay in approval of payment orders by client;
6) Obstruction of evidences and information flow;
7) Slowness of communication between contractor and client;
8) using administrative and supervision methods that concentrate on increasing customer satisfaction.

In order to prevent and avoid having or facing complicated administrative procedures in administrative structure of client or governmental offices the following actions are suggested for both

1) Use of experienced and professionals to train public authorities;
2) Removing paperwork at any time possible by public authorities;
3) Reduce the chain of command and the administration structure;
4) Contractors should increase the appreciation to functions of rules and regulations;
5) Knowing what are the rules and regulations, priorities and correct procedures to follow the issues to rectify and reach to end results;
6) Building a good relationship between contractor and administrative staff of client;

7) To be experienced in knowing the rules, regulations and hierarchical procedures in public organizations;
8) Following the issues to speed up the decision making processes by client.

Main unfavorable effect of bureaucracy in construction projects is delay at different stages of project. If all the efforts of contractor to prevent getting in trap of bureaucracy will not be successful, the following mitigation measures are recommended to reduce the side effect of it.

1) Compressing the duration of activities and revising schedules;
2) Assess the side effects and amount of causes delay;
3) Perform claim based on the contract;
4) Report the client immediately about the arisen delay due bureaucracy;
5) Issuance of written report to the client about the consequences of time consuming procedures due to bureaucracy and their responsibility on caused delay;
6) Asking client to decrease the number of layers to reach top management.

7.1.12 Inadequate Contractor's Experience or Poor Performance of Contractor

Contractor is one of the main parties of any construction project. Contractors are recruited by clients or owners of the construction projects to fulfill and realize their wishes. Generally, contractors participate in tender processes of construction projects that are associated with their field of work. Thereafter and commonly, they are selected based on the results of tender processes by client. Earlier than being selected by clients, contractors typically have to assess and evaluate the tender and contract documents including proposals, objectives and specifications of project. Key responsibilities of construction contractors are making adequate amount of necessary material,

manpower and machinery to deliver the project timely, within specified cost and with best quality. Therefore, attempting to follow these responsibilities accurately to deliver the project successfully to an end is quite important. This is not possible unless the contractor and its management team has good experience on management and performing the implementation of the project. This cause generally affects time of the project more adversely than its cost on construction projects based on the outcomes of DEA. Resulted poor performance of the contractor evaluation at the end of the construction projects might be mainly due to the following reasons (Tharanya & Pradeep, 2016), (Choma, 2008), (Olawale & Sun, 2010):

1) Poor contractor selection procedure by client;
2) Selection of unqualified contractor by client without tendering processes;
3) Selecting the contractor based on the lowest price and without paying attention to the past experiences;
4) Lack or low experience of contractor on the field of the project;
5) Poor contract management by client;
6) Contractor's inability to recognize problems;
7) Contractor's inability to quickly rectify the problems;
8) Poor knowledge of project management by contractor;
9) Poor knowledge on material management by contractor;
10) Poor capability of personnel and labor management by contractor;
11) Poor capability of equipment management by contractor;
12) Using inexperienced, unskilled or unqualified workers by contractor;
13) Poor technical knowledge of contractor's staff;
14) Poor control and management of subcontractors by general contractor;
15) Poor knowledge of schedule management by contractor;

16) Poor knowledge of cost management by contractor;
17) Failure to execute the contract properly by contractor;
18) Lack or poor regular inspections and control of contractor during construction phase by client;
19) Poor communication between contractor and owner;
20) Unfavorable financial condition or bankruptcy of contractor;
21) Unclear safety policies and inadequate precautions on the construction site by contractor.

Poor performance of contractor causes many problems during the project implementation phase. These problems show themselves as weak outcomes in compare with objectives and scope of the project. Followings are main consequences due to inadequacy of contractor's experience:

1) Poor quality of work;
2) Delay in finishing the project on time;
3) Budget overrun;
4) Accidents and safety issues in the site area;
5) Late recognition of the arisen problems;
6) Slowness in rectifying the problems;
7) Low profit margin of contractor;
8) Financial loss of contractor;
9) Additional works;
10) Reworks;
11) Increase the amount of disputes between contractor and other construction parties;

12) Low productivity of workers and equipment;
13) Increase of the amount of used resources;
14) Ineffective distribution of workers, plants and facilities;
15) Construction errors during construction phase;
16) Damage to construction equipment and facilities;
17) Abandonment or termination of contract by contractor;
18) Labors personal conflicts;
19) Unsuitable decisions for construction approaches;
20) Suspension of work by owner;
21) Claim by owner.

In any construction project both owner and contractor are looking for their own benefits throughout implementation and finalizing the project. Therefore, increase the performance of contractor is somehow vital for both parts. In the other word, good performance of contractor till the end of the project should be the common goal of both parties. In this direction, in order to make the performance of contractor acceptable, some preventive actions against adverse condition and causes should be taken by both parties. In some cases, employer assistance and cooperation can play an important role in enhancing contractor performance. Some preventive actions to cover misadministration and low experience of contractor might be as followings:

1) Proper selection of contractor based on their reference of past performances and implemented projects;
2) Grant the contract to contractor based on their capabilities and experience on doing the proposed project not only best price;

3) Conduction of proper project management training programs for management team by contractor;
4) Attending of workers of contractor in regular and proper training programs;
5) Timely payments by owner to contractor;
6) Approval processes and decision making procedures by client should be done timely;
7) Adopt an easy to access communication network;
8) Providing comprehensive drawings and plans supplementary data to contractor by client;
9) Recruitment of skilled and qualified subcontractors in the project;
10) Employment of adequate number of labor;
11) Employment of competent labor;
12) Timely payments by contractor to workers and subcontractors;
13) Prioritize and separate the importance from unimportant;
14) Timely performing the tasks and construction activities based on planned schedules by contractor;
15) Appropriate and in-time supply of resources (e.g. material, manpower) ;
16) On time delivery of resources to the site area (e.g. material, manpower);
17) Frequent inspections by consultant of project or client's legal representative in site area;
18) Implementation of clear policies and precautions and safeguards by contractor for engineers and workers;
19) Upkeep the equipment in ready to work and good operation condition;
20) Regular project meetings in between project parties;
21) Assigning the workers to the tasks that they are well qualified and capable of;

22) Timely attendance of workers and engineers of contractor at site area;
23) Prevent design changes during construction as much as possible by client;
24) Prevent scope changes during construction phase as much as possible;
25) Decrease or minimize the stoppages of construction tasks by contractor;
26) Efficient usage of resources by contractor;
27) Maintenance and repair the machinery continuously;
28) Providing a suitable place for employees to rest.

At each stage of the project implementation if the employer notices the contractor's poor performance, it is necessary to warn contractor and help to enhance the performance of the contractor. It is understandable that enhancing the performance of contractor is a win-win act. Employer and contractor both together, can analyze and resolve problems that arise better. Therefore, cooperation of client in this manner is quite important. Some mitigation measures to enhance the poor performance and experience of contractor are as followings:

1) Establishment of an experienced project management team by client to give consultancy to both client and contractor;
2) Dismissal and replacement of sub-contractors by general contractor;
3) Hard work to overcome deviations and deficiencies by contractor;
4) Recruitment of well experienced construction managers and workers;
5) Increase the productivity of workers to recover the caused delays;
6) Monitor and force contractor to have an effective distribution of workers in the site area;
7) Adoption of new technologies to recover and makeup the gone time;

8) Frequent regular meetings in between contractor, consultant, client or his/her legal representative;
9) Modifying or design changes;
10) Removal of unnecessary tasks that waste the time;
11) Adequate site supervision in coordination with management team of contractor and more tough inspection by employer;
12) Overtime;
13) Refer to a competent consultant to get recommendations for rectifying the arisen problems in shortest possible time;
14) Prevent assigning any more additional works due to design or scope changes to inexperienced contractor;
15) Dismissal and replacement of contractor based on the contract clauses by client.

It should be remembered that mitigation measures are taken at any point and any time after starting the project and especially during implementation time. Therefore, except the recommended mitigation measures, some of the preventive actions can be also taken to mitigate the effects of poor contractor performance from the point that this weakness is recognized.

7.1.13 Delay on Approval of Feasibility Study, Drawings and Materials

This delay is one of the major causes that affects time criteria at early stage of the construction project. Generally, the root cause of delays in approval has been largely attributed to government policy and bureaucratic procedural processes of the government. On the other hand, client is responsible for occurrence of this cause. In some construction projects, starting of any task is not allowed without written approval

of consultant or client. Therefore, as a consequence, project will experience delay unless the contractor receive approval from the legal authority for drawings and type of materials. Furthermore, in design and build contracts, this delay will stop the continuity of construction progress. The main reasons for occurrence of this type of delay might be as followings (Liu, Lam, & Fellows, 2006), (Lam & Liu, 2005) (Kpamma & Adjei-Kumi, 2013):

1) Incomplete or defective submitted feasibility study to client of the project;
2) Incomplete drawings and specifications;
3) Client's wishes which are beyond the contract;
4) Delay in submitting feasibility study to client;
5) Heavy workload of approval authority in client;
6) Long holiday period or non-working days;
7) Bureaucratic administrative and procedural processes;
8) Inter-organizational disagreement;
9) Unpredicted events;
10) Lack or Low experience of client/ project manager;
11) Lack or low knowledge of client about engineering drawings and construction materials;
12) Change in client's opinion on type or usage of the project;
13) Change in client's mind on type of previously decided construction materials;
14) Poor plans, designs and drawings;
15) Poor specifications of materials;
16) Poor financial condition of client;
17) Lack of due date deadline for approval process;
18) Absence of the key decision makers in client part;

19) Poor communication and coordination between client and consultant of the project.

Consequence of the aforementioned adverse cause is mainly would be as delay in delivery of the project. A list of probable primary and secondary short and long-term impacts are as followings:

1) Late start up with mobilization of contractor;
2) Failure in starting next task by contractor;
3) Uncertainty and suspension of dependent tasks;
4) Delay in delivery of the project on specified date on contract;
5) Delay in payment to contractor;
6) Initial delay in preparation of construction site by contractor;
7) Change in type of the project;
8) Change in type of materials;
9) Delay in material delivery to the site due to probable changes;
10) Financial damage to contractor of project;
11) Partly of full suspension of the work;
12) Change in scheduling of project;
13) Complain and claim by contractor;
14) Change in quality of work;
15) Safety issues in case of conditional approval and change in type of materials or drawings;
16) Failure of supplier to provide required materials timely;
17) Problem with sub-contractors and conflict with their scheduling;

To avoid facing the above-mentioned adverse consequences in construction projects, clients should take some preventive actions. According to the investigation on literature and interviews with experienced civil engineers and project managers, it is evidenced that the following preventive actions are most likely work if considered by clients:

1) Ensure that submitted feasibility report, drawings and specifications are adequate and complete;
2) Decentralization of the final approval process by client;
3) Considering client approval period delays during the early planning;
4) Ensure about availability of sufficient knowledge about the content of feasibility reports;
5) Hire experienced consultant for preparing feasibility report and drawings;
6) Appoint or contract with an experienced consultant or supplier to give consultancy;
7) Consider and ensure about the maximum allowed time frame of approval processes;
8) Ensure that the tasks under approval processes are not in the critical path;
9) Ensure and take responsibility for the effects of resulted delay due to delay in approval;
10) Efficient coordination with in charge in-house staff or in charge consultant;
11) Feasibility report should be provided by authorized party in the shortest time possible to for decisions by owner;
12) A due date should be assigned for submission of drawings and required materials by consultant;

13) A comprehensive list of different available and suitable required materials in the market and their advantages or disadvantages should be prepared and submitted to client;
14) Avoid payments to related authorities timely;
15) Accelerate the approval processes throughout frequent meetings with experienced project managers or in-house decision makers;
16) If there is lack of in-house capabilities, an experienced decision making team consisting of different expertise should be formed;
17) Use of lessons learned from previous projects for accelerate the approval of the materials;
18) Eliminating bureaucratic administrative and procedural processes;
19) Using new technologies to enhance communication and decision making ability;
20) Issuing partial permit by client;
21) Discharging of inexperienced decision makers.

Failure in timely approval of feasibility studies, designs and materials by client, causes loss or damage to contractor of project. Therefore, approval procedure should be done as fast as possible in order to prevent the adverse effects of it. As a result, this damage will be returned to the client in the form of claim by contractor. If performed preventive instructions are unsuccessful, following mitigation measures doable by involved parties to cover the adverse effects on contractor are recommended:

1) Allow extension of time with prolongation/disruption costs by client;
2) Accelerate the speed of ongoing tasks to makeup the lost time;

3) Start implementation of the parts that are not dependent to current approval processes;
4) Use of lessons learned in previous implemented projects;
5) Use of experiences of other contractors or project managers by asking them;
6) Negotiation with client and reschedule the activities;
7) Prepare to start legal claim procedures based on the contract by contractor;
8) Give the responsibility to contractor, if they have in-house capabilities by an agreement.

7.1.14 Underestimate and Inaccurate Appraisal (Missing Measures, Cost Adjustment)

Government departments and institutions are usually take the responsibility for carrying out large-scale construction projects. For this purpose, goals and objectives are targeted. To achieve these goals and objectives, the organizations required to assess the project alternatives and prioritize feasible plans after rejection of useless alternatives for implementation. If implementation of the project considered as a problem that is going to be solved, the most feasible alternative needs to be accurately appraised. Appraising a project is the initiation stage of the project. The outcome of Project appraisal is a document that includes a summary of time and cost estimations and made evaluations to validate the project idea and verify that the provided solution will solve the problem. Moreover the cost effectiveness and feasibility of the project will be discussed as a tool of project appraisal. (Mcconnell, 2019). According to the above definitions, it can be concluded that accurate and sound cost and time estimations and taken measures in any appraisal document have an important and starring role.

In current study, underestimate and inaccurate appraisal is ranked as the first critical cause that highly impact the cost criteria of large construction projects. Underestimation of costs arises when a more quantity of work or tasks, or a greater amount of materials and equipment, is necessary for the project execution than was projected at the appraisal time.

Similar to other studied causes, the root of the cause, consequences, preventive actions and corrective actions are discussed as followings (Medica, 2011), (Bipat, 2018):

1) Unnecessary optimism of estimators;
2) Undertaking of poor cost estimating techniques by estimators;
3) Inadequacy of cost information;
4) Too many ongoing project appraisals;
5) Limitation of time for submitting the appraisal documents;
6) Carrying out inappropriate cost estimation techniques;
7) Complexity of project;
8) Failure to make use of historical data;
9) Inaccurate and not meaningful primary data about the project;
10) Appreciation/depreciation of exchange rate against local currency in international projects;
11) Low rate of compensation for owner to pay;
12) Lack of understanding about the project by appraisers;
13) Lack of confirmation and verification of estimates during the project preliminary phase;
14) Ignoring risks and uncertainty (e.g. Inflation);
15) Inaccurate design;

16) Lack of detailed design;
17) Poor scope of work;
18) Change in scope of work;
19) Change of specifications and quantities;
20) Design changes;
21) Inadequate surveys on the site area;
22) Inaccurate prediction about quantities (e.g. volume of work);
23) Inaccurate usage of units or forgetting to insert units (e.g. kg and ton).
24) Long time gap between appraisal period and contract award.

Underestimate or overestimate and inaccurate appraisal has adverse effects on the outcome of construction projects. Some consequences of inaccurate cost estimations might be as followings:

1) Extra cost expenses;
2) Late completion of project;
3) Excess or deficiency of required resources;
4) Increase the number of claims by contractor;
5) Termination of contract by contractor due to shortage of client's fund;
6) Additional works;
7) Unbalanced resources during the project execution;
8) Contractor may offer inaccurate bid in tender processes and lose the competition in case of overestimating;
9) Contractor may bankrupt in case of underestimation;
10) In large projects, the client may face significant losses and unplanned costs if costs underestimated in appraisal stage;

11) Poor quality of implemented work.

As mentioned before, there are many reasons that make the estimations inaccurate. A faulty estimation will have headed the project to overruns from the inception of the project. The most important responsibility of cost estimators is to make the most accurate estimations. In order to get to this target some preventive actions should be taken. A number of probable actions are recommended as followings:

1) Project appraisal should be given to those who do not have many ongoing projects at the same time;
2) Adequate time should be allocated for appraisal phase;
3) Accurate and meaningful data should be provided to appraisers;
4) Refuse/Decline impractical project cost estimations;
5) Recruitment of skilled project managers;
6) Making sure that project planner/designer is well qualified in the construction methods and procedures;
7) Greater attention to corresponding of estimations and scope of project;
8) Greater attention to market prices during appraisal phase;
9) Effect of change in exchange rates should be considered in international projects;
10) Risk and uncertainties should be considered in appraisal report (e.g. inflation);
11) Cost estimates should be performed according to detailed designs;
12) Greater attention to the prices and conduction of an analysis over unit price growth factors;
13) Estimates should be reviewed, verified and validated before submittal date preferably by another estimation team if the deadline would not be missed;

14) Cost contingency plans should be considered;
15) Usage of historical data and lessons learned through previous experienced projects;
16) Refuse unrealistic cost estimations and appraisals by owner;
17) Perform estimations with advanced cost estimation programs;
18) Ensure about the accuracy of the cost allocation plan in different phases of the project;
19) Ensuring about appropriate and adequate price for activities is allocated in tender official papers;
20) Examination for any calculation errors, omissions and mistakes;
21) Review for any overlooked item;
22) Cost estimators should take part in design process.

Sometimes during the execution of the project the employer or the project contractor realizes substantial errors and inaccuracy in the appraisal of the project. Those problems would result in damage to both client and contractor party. In order to lessen the effects of the aforementioned problem the following mitigation actions are recommended:

1) Request a second appraisal from appraiser or another external consultant;
2) If the costs are overestimated by client's appraisal team, client has to stop payments;
3) Integrate a cost management plan to scope of project;
4) Request an urgent meeting between responsible people on project cost estimates and assessment;
5) Adding an amendment to the signed contract;

6) Providing additional counterpart funds by client.

7.1.15 Change in Exchange Rate

Exchange rate is defined as the worth of one currency in compare to other currencies. When this value starting to change against other currencies, change in exchange rate arises. It is not at all times possible to accurately predict accurate amount of change in exchange rate during implementation of construction projects. Nevertheless, it can be expected as an uncertain risk and can be foreseen in estimations and appraisal stage. This cause directly and indirectly affecting all parties involved in the construction projects including client and contractor. This change might be in appreciation or depreciation form of currency which might be beneficiary or lead to loss. In this part of study, adverse effects of the change will be discussed.

Change in exchange rate may have adverse significant impact on international projects where foreign contractor is paid in another currency like dollar and they pay their workers in local currency like Turkish lira or in the opposite form. Therefor this cause should managed continually and sensibly (Philpot, 2019).

This uncertain adverse cause is identified and ranked as the second major problem that is responsible for cost overrun in large construction projects in current study. The main causative reasons for occurrence of this problem are often out of control for the client and the contractor. A list of possible main reasons that are foundation for occurrence of this cause are listed as followings:

1) Increase in the amount of given interest by the central bank or private banks;
2) Balance of trades of country;
3) International or national debt of central government;
4) Political issues and events,

5) Financial policies of central government;
6) Recession.

Change in exchange rates, substantially and adversely influence large international construction projects. In this regard, if negative effects of the variation in exchange rate have not be considered carefully earlier, effects of the change have consequences as followings:

1) Cost overrun;
2) Delays in progress of projects;
3) Decrease or compromised quality of the work due to monetary problems;
4) Relative price escalation of raw materials;
5) Relative price escalation of imported construction equipment and materials,
6) Delay in importing required materials;
7) Increase in price of materials;
8) Loss of client or contractor based on the type of contract;
9) Reduction of profit margins;
10) Reduction of the revenue;
11) Suspension of the project;
12) Change in salary of international workers and staff.

Exposure to fluctuations in exchange rate has adverse effects on the construction projects. In order to prevent experiencing aforementioned effects in the consequences part, certain preventive actions and manners should be taken by project managers. Following indicated points are probable preventive actions to avoid adverse effects of this cause:

1) Predicting the exposure to variation in exchange rate before purchasing;

2) Advance payments to suppliers before probable change in exchange rate;
3) Supplying all required materials and equipment for whole project before being a victim of change in exchange rate;
4) Local currency fluctuations should be considered in contract of international projects;
5) Usage of currency options for contractor in contract;
6) Locking the exchange rate value by setting it as a base rate up to a certain date in contract;
7) Possible risks and effects of currency exchange rate on contracted project should be considered and allocated by client and contractor in the contract;
8) Alternative solutions for drastic rate changes should be foreseen in the contract;
9) Client payments should be done in foreign currency in international projects;
10) Using forward contract type to buy and sell currencies at a fixed rate during contract period;
11) Insurance the project against currency fluctuations;
12) Have a contingency plan for fluctuation in exchange rate;
13) Sign an agreement with client to make available all the materials and equipment that need to be provided and bought by foreign currency.

In some cases, despite predictions and knowing about what will happen due to currency fluctuations, preventive actions are not adequate enough. Therefore, currency fluctuation starts affecting the construction project. These effects are mostly influence cost and then time and quality of the project. During occurrence of price fluctuations, following controlling measures are recommended:

1) Identification of the type of fluctuation in exchange rate;

2) Measuring the effected parts due to fluctuations;
3) Find low-cost materials with close quality to the one required in the specification document;
4) Reduce or change in preference of foreign produced materials on local products;
5) Renew cost plans;
6) Employment of local workers and staff;
7) Employment of implementation methodologies with lower cost;
8) Discuss with other parties to rectify or minimize the effects of currency fluctuations according to the contract;
9) Suspension of project and pay the compensation to other contracted party;
10) Evaluate and order purchase of materials from the most important to less important.

7.1.16 Inaccurate Initial Project Scope

Project scope is defined as "The work performed to deliver a product, service, or result with the specified features and functions" (Project Management Institute, 2013). In other definition "project scope is the part of project planning that involves determining and documenting a list of specific project goals, deliverables, tasks, costs and deadlines" (Rouse, 2018). Basically, all the project plans, time and cost estimations, procurement and quality requirements are generally obtained, assessed and calculated based on initial project scope. Therefore, accurate and well defined initial project scope is of a high importance and vital. This cause is ranked as third important cause that impacts the cost of large construction projects. Generally inaccurate initial project scope occurs due to the following reasons (Adamu, 2018):

1) Inadequate and/or incorrect data and information;

2) Misunderstanding of planner and designers about what exactly required by client;
3) Defective and vague goals and tasks to achieve the client's requirments;
4) Pressure by client for fast preparation of necessary documents;
5) Financial limitations of client to reduce planning costs;
6) Complexity of project.

Inaccurate initial project scope has serious consequences when it comes to large construction projects. Consequences of this cause are mostly the followings:

1) Costly changes;
2) Rework;
3) Revision of scope of the works;
4) Change in scope of project or deliverables;
5) Delay in delivery of the project;
6) Budget exceed; overspent project
7) Low profit margin;
8) Excess /Shortage of materials on demand;
9) Arbitration disputes;
10) Litigation;
11) Suspension of works;
12) Revocation of contract;
13) Additional works;
14) Change orders;
15) Resources will be diverted to new activities that were not planned to use in the original project;

In order to prevent facing inaccurate initial project scope, especially in large construction projects, certain preventive actions should be considered. Following items are recommended anticipatory actions:

1) Clients should provide a clear and brief scope of work;
2) Clients should be aware of the consequences of change in scope of the work;
3) Verification of scope documents before submitting to client;
4) Comprehensive appraisal of the project before starting the bidding process;
5) Available data for estimation should be accurate and current;
6) Ensuring the project planner is well skilled in the construction methods;
7) Use competent, qualified and skilled cost estimators;
8) Cost estimators should participate in design process;
9) Examination for any mathematical errors, omissions and mistakes in calculations;
10) Double check for any plan, drawing or specification errors;
11) Refuse/Decline impractical project cost estimations;
12) Control the cost allocation plan in different stages of the project;
13) Refuse/Decline impractical project schedule deadlines;
14) Developing the project cost plan using experienced planners;
15) Make sure that sufficient fee for activities is allocated in tender documents;
16) Review the estimates by an external competent person;
17) Control the unit of the related costs;
18) Cost estimate should be based on price of available materials in the local market;
19) Consultants should ensure that the design and specifications fall within the approved budget;

20) All drawings and designs should be ready in tender stage to learn about any inaccuracy and probable mistakes;
21) Continually observing the progress of the project for avoidable errors.

In order to lessening the impacts of the studied cause, effective mitigation measures and efforts in this manner should be taken and done. The following corrective actions might reduce the effect of the inaccurate initial scope of project:

1) Timely informing different involving parties in the project of unforeseen issues;
2) Asking client to provide scope modifications in writing to contractor;
3) Timely meeting with client to find a solution and common points;
4) Ensure change order is placed immediately;
5) Adjustment of baselines;
6) Collect neccassary data and information;
7) Ensuring that required change is done with minimum cost and time;
8) Analyze impacts of the cause on the project;
9) Integrate a suitable change management plan to scope of the project;
10) Employment of lessons learned from previous projects;
11) Revise implementation methodology;
12) Revise budget;
13) Revise schedule;
14) Prioritize tasks;
15) Asking for compensation payable by client;
16) Reinitiation of work by contractor should be correspond to receiving a formal scope-change instruction by cleint;

17) Modified tasks should be reviewd by all included parties in construction in the shortest time;
18) Timely implementation of the changed tasks.

7.1.17 Fluctuation and Escalation in Prices (Materials, Machinery, Labor, Equipment)

Inflation or fluctuation in prices are commonly occur in countries with poor or unstable economy condition. In general, in large construction projects, contractors are required to submit their proposal based on the current or an agreed date prices. It is known that, large construction projects take a long time for implementation. Due to this reason, during the implementation period, there might be a change or some amount of fluctuations in the prices of materials, equipment and labor owing to inflation. If inflation was not predicted in contract, fluctuation in prices will affect the construction projects significantly. Based on obtained results in this study, inflation is ranked as fourth significant cause that highly impact cost of large projects. The main root causes of inflation are as followings:

1) Debt of local country;
2) Exchange rate;
3) Increase and excess demand of raw materials;
4) Demand is less than supply;
5) Devaluation of currency;
6) Interest rate policies;
7) Monopoly of raw materials by suppliers;
8) War;
9) Political issues;
10) Currency policies;

Fluctuations in prices has significant impacts on different aspects of construction projects. Some consequences of inflation are as followings:

1) Cost overrun;
2) Poor project management performance;
3) Poor productivity;
4) Compromised or poor quality of work;
5) Increase price of material delivery to the project site;
6) Delay in delivery of materials;
7) Delay in delivery of project due to financial problems;
8) High cost for purchase, rent or lease the equipment;
9) Higher cost of skilled worker employment;
10) Cash flow difficulties of contractor;
11) Low profit margin;
12) Loss of client and/or contractor;
13) Bankruptcy;
14) Suspension of work;
15) Abandonment of project by contractor;
16) Dispute between involved parties.

Due to the substantial problems which arises by inflation, predicting price fluctuations in planning phase is of a high importance. Moreover, contractors should consider effects of probable inflation before signing the contract. To prevent relevant consequences of inflation, following preventive actions are recommended:

1) Conduct an investigation to predict trend of inflation (if there is any) in the country and project implementation region;

2) Predicting of exposure to fluctuation in prices;
3) Following the price changes from bid time up to project delivery for early identification of issues;
4) Fixed purchase price growth contract with supplier;
5) Inclusion of a clause to contract regarding to time and circumstances of cost adjustments and reviews;
6) Using forward contract type to buy materials at a fixed price during contract period;
7) Prediction of contingency cost;
8) Adding a contract clause regarding to price fluctuation of materials and provisions to compensate changed prices;
9) Advance payment to material suppliers and buy required material for project;
10) Supplying required materials and equipment for whole project;
11) Locking the wages and salaries up to a certain dates in contract with workers and staff;
12) Allocation of the consequences of inflation between client and contractor;
13) Solutions for extreme inflation rate should be foreseen in contract;
14) Risk transfer to each of contract correspondents; (e.g. purchasing required risky materials and equipment by client)
15) Effective human resources (HR) management.

If taken measures to prevent negative effects of inflation were not be sufficient, consequences during implementation phase would be inevitable. Consequences typically affecting cost, time and quality of construction projects. In order to lessen the consequences, corrective actions are required to be taken. Followings are

recommended to take suitable corrective actions to minimize the abovementioned adverse effects:

1) Continuously track price changes;
2) Paying more attention to cost and time management;
3) Identify the affected parts of the project due to inflation;
4) Quantify the consequences of inflation on time and cost of project;
5) Urgent meeting with client to discuss and find a solution which satisfies both parties;
6) Agreement for change the materials to cheaper ones with similar qualities mentioned in specification;
7) Renew cost plans;
8) Conduction of a survey to employ implementation methodologies with lower cost;
9) Reevaluate the number of required workers at the construction site to save payments to excessive workers;
10) Renting the equipment might help;
11) Revised and better material usage management (e.g. Steel bars);
12) Terminate the contract and pay compensation to owner;
13) Reduce waste of materials and worker's working time;
14) Reduce and balance the number of workers and staff.

7.1.18 Additional Project Management, Consultancy, and Administration Costs

Generally, in appraisal and planning phase, a comprehensive cost estimate for projected project are done. At this phase, all project costs including project management, consultancy and administration costs are forecasted, assessed and calculated from inception to delivery date. An accurate cost estimate avoids the client

and/or contractor from losing money and falling into cost overrun. Sometimes the work condition goes so far that project management or consulting and administrative costs increases as opposed to forecasts. According to results of the sensitivity analysis, additional project management, consultancy and administration costs is 6th major reasons for cost overrun in large construction projects. The following factors are responsible for increase the project management, consultancy and administrative costs:

1) Delay in project;
2) Redesign or design changes;
3) Additional works;
4) Change orders by client;
5) Poor communication between construction parties;
6) Poor project management;
7) Poor consultation;
8) Poor experience of project managers;
9) Inexperienced engineers in consultant company;
10) Unrealistic or impractical cost estimations;
11) Lack or inadequate contingency plans;
12) Underestimating or missing project cost elements;
13) Inaccurate appraisal;
14) Inflation
15) Salary payment fluctuations;
16) Dismissal or change of consulting company;
17) Dismissal or change of project management team;
18) Claim by consultant;
19) Claim by project management team;

20) Employment of an external consultancy company;
21) Employment of an external project management team.

Likely consequences of this cause are as followings:

1) Cost overrun;
2) Poor productivity due to over budget condition;
3) Loss or low profit margin for involved parties;
4) Late payments by client;
5) Disputes.

To avoid imposing additional costs to project, following preventive actions should be taken:

1) Ensuring that cost estimators are competent, skilled and qualified;
2) Make sure that sufficient fee for project management and consultancy are estimated and allocated;
3) Scope of work should be clear and comprehensive;
4) Strictly tracking and following the deadlines;
5) Make all possible efforts to stay within the scope of project as much as possible;
6) Make all possible efforts to finish project on schedule;
7) Setting strict rules in contract for any type of monetary change for project management and consultancy payments;
8) Check the capabilities of project management team for proposed project before hiring;
9) Check the competences of consultant company before signing the contract;
10) Review the accuracy of cost estimation documents;

11) Review the accuracy of structural designs and their accordance to the latest legislation;
12) Avoiding any scope or design change as much as possible which needs redesign or new project management tasks to contractor;
13) Avoiding issuing of Change orders by client;
14) Continuous and uninterrupted communication in between construction parties;
15) Existence of a contingency plan in appraisal;
16) Allocation of effects of inflation in contract between construction parties;
17) Contract based on a fixed price with contractor and consultant;
18) Avoiding dismissal of contractor of consultant of the project as much as possible;
19) Trust to in-house capabilities for consultation or project management if there is any.

In order to reduction the impacts of additional imposed cost, efforts through applying effective mitigation measures should be directed. The following corrective measures might decrease the effect of this cause:

1) Transfer liability of the payment for additional costs to the contracting party that incurred the additional costs;
2) Timely meetings with contractor or consultant of the project to find an acceptable solution for additional payments;
3) Ensure the change of in charge company in implementation or consultancy take effect in the shortest time;
4) Revise budget;
5) Prioritize stopped or ongoing tasks;

6) Decrease or remove unnecessary costs;
7) Applying strict cost saving plans;
8) Usage of in-house personnel skills, capabilities and experiments if there is any.

7.1.19 Increase or Change in Scope of the Project

One of the main challenges for a project manager is to face with scope changes. Generally, clients have interest to add new features and expand the project during implementation phase. These expansions normally are not planned and designed in feasibility and appraisal stages. These changes if accepted, lead the project to a critical change from the original scope. Therefore, it is essential to know what are the roots and consequences of scope change on the different criteria of construction projects.

The main reasons for variations and change in scope of project are as followings (Prasad, Vasugi, Venkatesan, & Bhat, 2019):

1) Change of the client;
2) Absence of client during scope definition;
3) Change in requirements of project;
4) New opportunities for ongoing project;
5) The seemingly deemed interesting and useful demands of the client to expand the project;
6) Adding to the scope due to missing necessary features;
7) Increase the scope due to lack of clarity in original contract documents;
8) Detection of new needs parallel to project implementation;
9) New or excess budget in hand;
10) Good implementation performance by contractor;
11) Change or excess of available resources and materials;

12) Change in schedule of project;

13) Change in legislations, standards, rules and regulations;

14) Employment of new technologies;

15) Remedial actions during implementation phase;

16) Technical changes;

17) Inflation;

18) Shortage of construction materials;

19) Unforeseen issues;

20) Execution of contingency plans;

21) Added value changes to the scope of project.

Likely consequences of scope changes during implementations might be as followings:

1) Cost overrun;
2) Delay in delivery of the project;
3) Poor quality of work;
4) Suspension of work;
5) Budget exceed; overspent project
6) Dispute;
7) Arbitration disputes;
8) Litigation;
9) Low profit margin;
10) Revocation of contract;
11) Additional works;
12) Change orders;

13) Excess resources will be diverted to new activities that were not planned to use in the original project;
14) Need for new resources;
15) change in project deliverables.

It is vital to be ready for taking preventive actions against any change in scope of the work. Since most of the project managers are aware of the serious consequences of changing in scope of the project, it is important to apply methods to prevent undesirable consequences. Some of recommended preventive actions are as followings:

1) Wide-ranging construction site investigation before signing the contract;
2) Investigate and provide a list of the best plans that best fit with the client's need;
3) Identify and predict the conditions that increase or change in scope of project may occur;
4) Comprehensive appraisal of the project before starting the bidding process should be done;
5) Client should provide a clear and brief of requirements under the scope of work;
6) Probable demands of the client should clearly be within the scope of the work;
7) Ensuring the project planner is well skilled in the construction methods;
8) Refuse/Decline impractical scope changes;
9) Double check for any plan, drawing or specification errors;
10) Review the feasibility of scope of the project by an external competent person or team;

11) All drawings and designs should be completely ready in tender stage;
12) Always pursue written approval for changes from client;
13) Instruction for changes in scope of the project should clearly written in contract;
14) Limit the financial amount of scope changes to a percentage of total cost of project.

If the answer for the following questions are positive and client accepted to increase or modify scope of the project, corrective actions to save time and money should immediately start:

1) Increase or change in scope of project is really necessary?
2) If the scope change is beneficial for the project or not?

Meanwhile a written formal change of scope order according to clauses of contract should be issued by owner to contractor.

Recommended mitigation measures for increase or change in scope of the work are as followings:

1) Start the change management procedures;
2) Compressing construction durations as much as possible to finish the project on time;
3) Ensuring that change order is placed immediately by owner;
4) New items should be evaluated and new prices should be obtained;
5) Usage of contract clauses to cover time extension;
6) Usage of contract clauses to compensate additional costs;

7) Start-up should only be carried out if the price and timing of the added parts are agreed upon by the parties;
8) All changes and their impact on time and cost of project should be documented to prevent disputes between parties;
9) Make sure that all added features are implementing in a way that satisfies client;

Chapter 8

WEB-BASED ADVISING SYSTEM FOR CONSTRUCTION PRACTITIONERS

8.1 Introduction

In this chapter, brief information about the necessity of developing a website for construction practitioners are given. Moreover, different pages of the website are introduced.

8.2 Importance of Knowledge Management

Each construction company struggles to survive in the construction market by some means. Nowadays, their survival excessively requires the use of modern management and information tools. It is due to reason that if they cannot reduce their cost and increase their performance in time and cost management of projects, they will have no place in the competition.

In the process of implementation and management of construction projects, one of the important problems, is the lack of access to information and past experiences. Lack of access is occurred due to lack of documentation culture and availability of documented responsive and experienced solutions. Therefore, re-experience same problems, rework, repetition of errors and inaccuracies will be an inevitable consequence.

Another important problem that construction companies are facing is, the resignation or dismissal of key personnel who are/were involved in the implementation and

management of current or previous projects. By quitting the abovementioned experts from companies, all the experiences in the mind and memory of those people will also go with them. The cost, likewise the previous case, is to spend a plenty and great amount of time and money for re-experiencing problems and trying to solve them.

Therefore, to achieve better results in project management outcomes, gained experiences should be carefully recorded for the reuse of current and future managers of the organizations and construction companies. In the better word, documentation is one of the most effective knowledge management tools and can help to transfer knowledge and experiences gained to project managers.

8.3 Web-based Advising System

In the process of construction management, arisen critical problems are often very easy to solve. Often these causes are not taken serious by project managers. Therefore, they re-experience difficulties in control the time and cost and lead to repetition of same unsuccessful experiences including frequent managerial mistakes and rework. Due to this reason, past experiences should be well-gathered and documented by construction organizations and companies. Moreover because of the nature of construction projects, accurate and complete documentation requires the use of appropriate information technology tools, including information systems.

Use of past experiences of project managers and organizations is one of the most effective ways to control and reduce the cost and time, reworks and mistakes in projects. It is also increases the productivity of construction companies by showing the mitigation or elimination methods against adverse causes of time and cost overrun.

Due to abovementioned importance, past experiences should be used as a tool and guide in management of construction projects by project managers. Also concerns about use of past experiences and lessons learned made large organizations like World Bank (WB), ADB, and large companies to ask their staff to document and share their experiences in the projects publicly. For instance, ADB disseminates these documents as project completion reports publicly for use of professionals.

Project completion reports and academic research documents are generally, long and full of details. Therefor fully reading of several project completion reports, academic studies and lesson learned documents seems to be time consuming task for most of project managers.

Kivrak et al. stated that capturing obtained data and information in construction projects is a boring task. They also indicated that knowledge is typically experience based, tacit, and hard to transfer to others (Kivrak, Arslan, Dikmen, & Birgonul, 2008).

In this regard, there is a need for an easy to access, informative, handy, less time consuming, summarized and comprehensive advising system to project managers. Existence of this system is considerable and would help construction companies and project managers to make better decisions in control of time and cost.

In order to fill this gap, obtained results in this study were used and published in a website. All the studied critical causes and their unfavorable effects, side effects, preventive actions and corrective measures were published in a website as an advising system for construction managers and practitioners. This, will facilitate easy access of

construction managers to use solutions of this study for their cost and time control problems.

8.4 Guide to Website

First of all, it should be stated that projected website in its first version is very simple designed, so that anyone with any level of knowledge of the Internet can use it easily. In this website, causes of time and cost overrun are categorized into six different groups relative to owner, contractor, consultant, economic, material, equipment and manpower and external causes. Moreover, for ease of access to all identified causes in this study, a separate page is linked to the main page which includes all cause without categorization, sorted alphabetically.

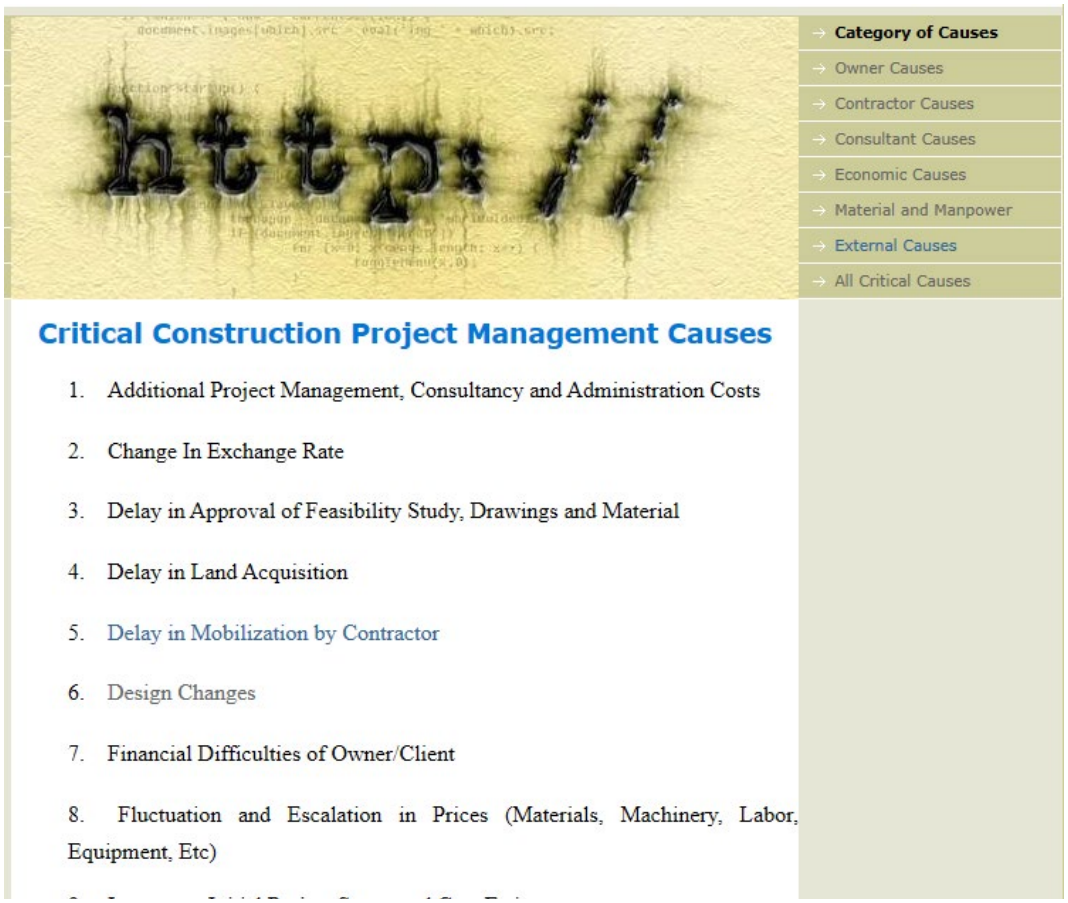

Figure 8: All critical causes of time and cost overrun in large projects

Figure 8 shows a part of the page that contains all critical causes of time and cost overrun listed. Each of causes are linked to their special pages which consists of four different parts. Roots of cause, consequences of experiencing the cause, recommended preventive actions and mitigation measures page respectively. As it is shown in Figure 9, a brief introduction for delay in mobilization by contractor is given. Moreover related further information for this cause is available through four sub-pages.

Figure 9: Page of delay in mobilization by contractor and its sub-pages

As it can be seen in Figure 9 by clicking and following each of the provided links, roots of the cause, consequences, recommended preventive actions and mitigation measures will give further information as it is shown in Figure 10, 11 and 12. As a result visitors of the website can access to their required information about the related cause.

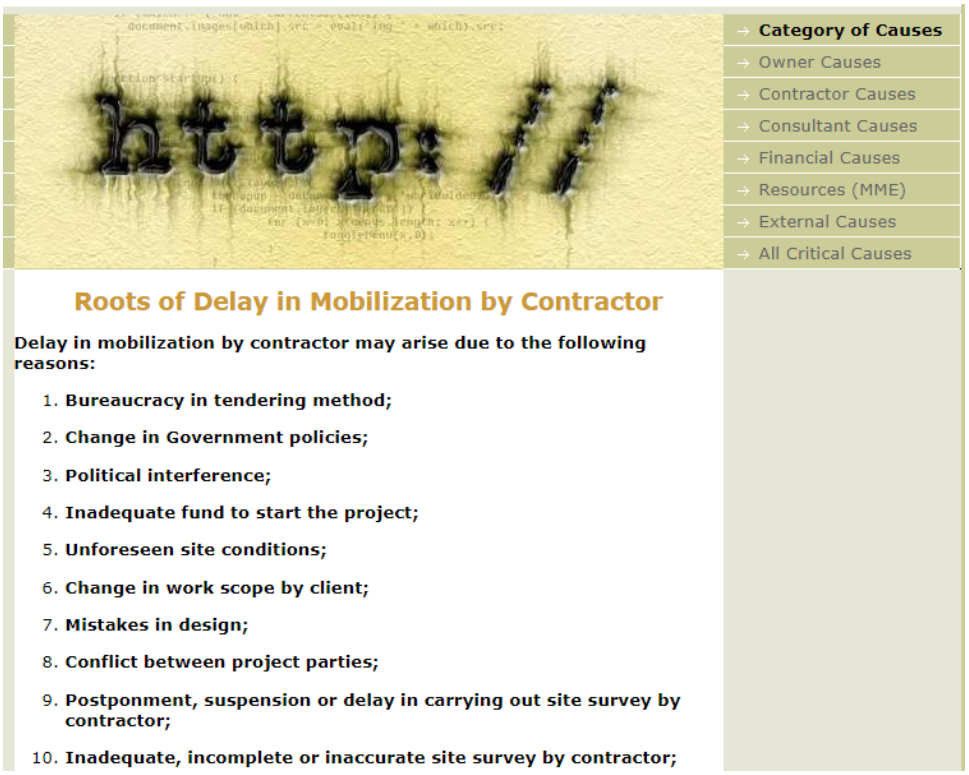

Figure 10: Roots of delay in mobilization by contractor

Figure 10, shows probable roots for “delay in mobilization by contractor”.

Figure 11: Consequences of delay in mobilization by contractor page

As can be seen in Figure 11, identified consequences of the abovementioned adverse cause are listed respectively.

Figure 12: Preventive actions for delay in mobilization by contractor page

As Figure 12 demonstrates, after a brief introduction, this page provides short and useful strategies to deal with the problem. Visitors can use a range of strategies depending on their job position.

It should be added that, at the end of each of the pages a hyperlink is provided to get comments and suggestions of visitors to enrich the website with new, additional and missing information about each of the causes. After receiving the required position and job related information of the visitor, the visitor will be asked to provide additional suggesstions and comments about the visited page accordingly.

This will give ability to the owner of the website to update the content after a revision and make it more better for the use of construction practitioners. Figure 13 simply shows the above-mentioned form.

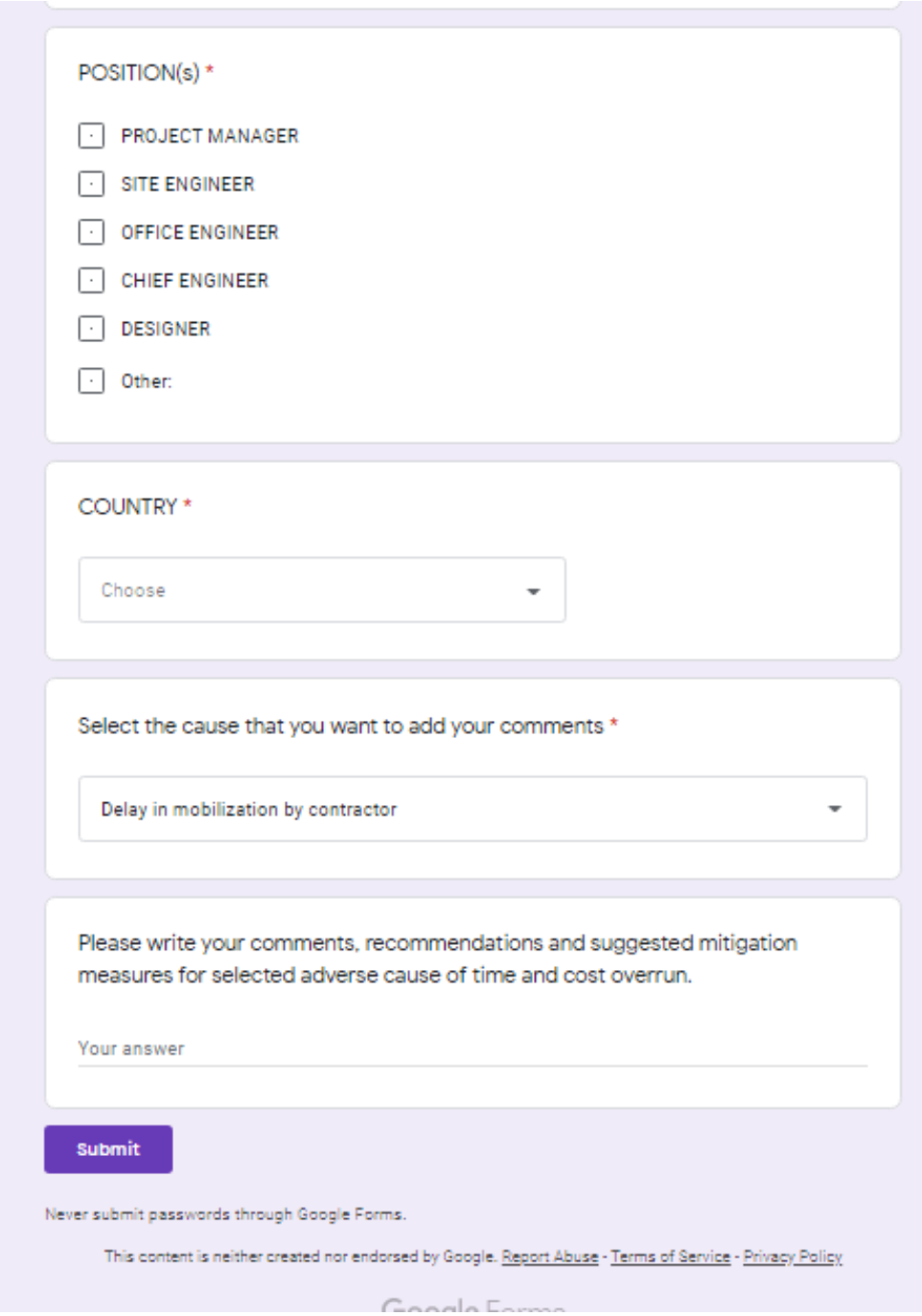

Figure 13: Suggestion and recommendations form

8.5 Future Plans

This website is developed based on the comprehensive literatures, interview with the experts and experiences of author. It is believed that, in the light of comments and suggestions from website visitors and experts, the quality and quantity of provided information will greatly improve. Therefore, in advanced version of current website, efforts will focus on make changes to upgrade it from static type to a dynamic one. In addition to that add new directions capabilities like a discussion board for the use of practitioners and construction managers is planned for the future.

Chapter 9

CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

In current study, the survival of cost and time overrun phenomena in large-scale construction projects across the world especially in East Asia, Africa and Middle East region countries, was proved by an in depth investigation in literature and extensive study on more than sixty large construction projects supported by ADB. Thereafter, significant causes responsible for time and cost overrun in large projects were identified. Afterward, time and cost management efficiency was defined and the most significant causes affecting them was investigated and recognized. In the next step, main roots and consequences of adverse causes of time and cost management efficiency was investigated. Moreover, an investigation on how to deal with adverse causes before occurrence and after happening was carried out. As the last part of the current study, an easy to access, informative, handy, less time consuming, summarized and comprehensive advising system to project managers was developed.

In accordance with the objectives of this research:

1) Sixty-six adverse causes responsible for time delay and cost overrun was identified separately. This identification was done as a result of comprehensive literature review, an in depth study and review of sixty-three ADB project completion reports as case studies and interview with construction industry practitioners. Thereafter the frequency of occurrence for each of adverse causes

in case studies were carefully driven and counted. Subsequently amount of time and cost overrun for each case study were calculated.

2) In the next step, consequences of each of the causes on time and cost criteria was identified. Time and cost overrun were the main consequences of the adverse causes;
3) By the means of DEA, relative performance of project managers in controlling time and cost of case studies were computed separately;
4) Thereafter, the most significant causes of time and cost management performance was identified and ranked separately. As a result, in terms of time management efficiency, “delay in mobilization by contractor”, “design changes”, “poor project management and supervision” and “severe weather condition” are the four important frequent causes that critically influence the time management performance of projects. Also according to the obtained results “fluctuations and escalations in the prices of material, equipment and labor”, “change in exchange rate”, “underestimated and inaccurate appraisals” and “increase in the land acquisition price and compensation” ranked as the most significant causes affecting performance of project managers in cost control aspect respectively.
5) Results of the assessment by DEA was also shown that “additional works”, “inaccurate initial project scope”, “increase or change in the scope of the project”, and “design changes” are four common critical causes that strongly impact both time and cost management efficiency.

In addition to previous parts, a sensitivity analysis on the adverse causes of time and cost overrun was also performed. The aim of this stage was to investigate the significance and influence degree of frequent adverse causes on time and cost management performance. Outcomes of sensitivity analysis showed that “design changes”, “delay in mobilization by contractor” and “poor project management, construction management and supervision” have greater influence on time management efficiency. Similarly, results showed that, “underestimated and inaccurate appraisals”, “changes in the exchange rate” and “increase in quantity of works” are the serious causes that cost management efficiency is more sensitive to them:

1) According to the results of sensitivity analysis and an extensive investigation on efficient and inefficient DMU’s it is shown that time management performance is more severe than cost management performance. Based on the obtained results, in case of poor time management performance by project managers, the probability of inefficient cost control is about 4 times higher than that of efficient cost control. Besides, it is shown that, good performance in cost control will mostly resulting in efficient time control rather than poor time control.
2) In another important part of current dissertation, an extensive investigation on significant causes of time and cost overrun was done. It is believed that, to overcome the adverse causes of time and cost overrun, nature of causes and their creation roots and direct and indirect consequences of them should be carefully and accurately identified. Therefore, another investigation was performed to identify the origin of causes and their consequences. After well identification of causes comprehensive solutions to oppose time and cost

management performance causes was given according to their roots and consequences;

3) In the final stage of current investigation, a web page based on the outcomes of the previous part for the use of construction practitioners and project managers was developed. In this webpage, for each of the adverse causes of time and cost overrun, relative preventive actions and mitigation measures are suggested and recommended. It is believed that this webpage will help construction managers in opposing adverse causes of cost and time management.

9.2 Limitations of This Research

The constraint of this investigation is that, this research was performed based on projects implemented and completed in Asia region. Also chosen projects were among Asian Development Bank transportation projects. Moreover, sum of studied projects were limited by the number of construction projects that experienced time and budget overrun. Finally, the assessed completion reports offer extensive information including reason, and results of the problems for time and budget overrun. It should be stressed that, the attained conclusions for this part of study are limited to the selected project's data and reflected criteria for those projects only.

9.3 Further Works

According to the outcomes and achievements of current investigation, following recommendations for further research are given as below:

1) In the area of cost and time overrun, it is recommended to categorize and conduct research based on type of construction project (e.g. Building projects, road projects, etc.)

2) Given that each country has its own culture of workers, unique circumstances and characteristics, it is recommended that, investigations be conducted for each country separately;
3) Mitigation measures could be studied further by categorization based on the project type, contract type, project delivery system and involved party.
4) Advantages of DEA can be extensively used and applied for asses of managerial performance of project managers in not only in controlling other aspects of project management like health and safety but also in decision making for project delivery system, contract type, satisfactory of stake holders and quality rather than only time and cost aspects;
5) Grading of construction companies based on their time and cost performance might be investigated;
6) Grading of project managers according to their performance in controlling time and cost can be investigated and offered as a systematic procedure for internal assessment by means of DEA;
7) Applicability of using time and cost management efficiency score for decision making to select the best bidder in tender process can be another area of investigation;

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APPENDIX

Scholary Studies on Cost and Time Overrun

#	Year	Title of Research	Author(s)
1	1985	Reasons For Delays In Public Projects In Turkey	Arditi, D., Akan, G. T., & Gurdamar, S.
2	1986	Delays On Large Construction Projects	Sullivan, A., & Harris, F. C.
3	1988	Causes Of High Costs Of Construction In Nigeria	Okpala, D. C., & Aniekwu, A. N.
4	1995	A Study Of The Factors Affecting Construction Durations In Hong Kong	Chan, D. W., & Kumaraswamy, M. M.
5	1997	Factors Influencing Construction Time And Cost Overruns On High-Rise Projects In Indonesia	Kaming, P. F., Olomolaiye, P. O., Holt, G. D., & Harris, F. C.
6	1997	A Comparative Study Of Causes Of Time Overruns In Hong Kong Construction Projects.	Chan, D. W., & Kumaraswamy, M. M.
7	1998	Causes Of Delays In The Construction Industry In Lebanon	Mezher, T. M., & Tawil, W.
8	2000	Construction Delay: A Quantitative Analysis.	Al-Momani, A. H.
9	2000	A Preliminary Study Of The Factors Affecting The Cost Escalation Of Construction Projects.	Knight, K., & Fayek, A. R.
10	2000	Midicon: A Model For Mitigating Delays In Construction.	Love, P. E. D., Li, H., Irani, Z., Treloar, G. J., & Faniran, O. O.
11	2000	Causes Of Delay In Construction Projects: A Quantitative Analysis	Viles, E., Rudeli, N. C., & Santilli, A.
12	2000	Assessment Of Cost Control System: A Case Study Of Thai Construction Organizations.	Sriprasert, E.

13	2000	Schedule Delay Analysis.	Stumpf, G. R.
14	2001	Construction Delay Computation Method.	Shi, J. J., Cheung, S. O., & Arditi, D
15	2001	Time-Overrun Factors In Nigerian Construction Industry.	Elinwa, A. U., & Joshua, M.
16	2002	The Effects Of Construction Delays On Project Delivery In Nigerian Construction Industry.	Aibinu, A. A., & Jagboro, G. O.
17	2002	Causes Of Construction Delay: Traditional Contracts	Odeh, A. M., & Battaineh, H. T.
18	2002	Project Cost Overruns And Risk Management	Jackson, S.
19	2002	Reasons For Cost And Schedule Increase For Engineering Design Projects.	Chang, A. S. T.
20	2003	Delays In Construction: A Brief Study Of The Florida Construction Industry	Ahmed, S. M., Azhar, S., Kappagntula, P., & Gollapudil, D.
21	2003	Causes Of Delay And Cost Overruns In Construction Of Groundwater Projects In A Developing Countries; Ghana As A Case Study	Frimpong, Y., Oluwoye, J., & Crawford, L.
22	2003	Significant Factors Causing Delay And Cost Overruns In Construction Of Groundwater Projects In Ghana.	Frimpong, Y., & Oluwoye, J.
23	2003	How Common And How Large Are Cost Overruns In Transport Infrastructure Projects?	Flyvbjerg, B., Skamris Holm, M. K., & Buhl, S. L.
24	2003	The Root Causes Of Delays In Highway Construction.	Ellis, R. D., & Thomas, H. R.
25	2003	Contributors To Construction Delays In Palestine.	Enshassi, A., Liska, R., El-Sawalhi, N. I., & Radwan, I.

26	2003	Identifying The Important Causes Of Delays In Building Construction Projects.	Alwi, S., & Hampson, K. D.
27	2004	Impact Of Construction Materials On Project Time And Cost In Kuwait.	Koushki, P. A., & Kartam, N.
28	2004	Large Construction Projects In Developing Countries: A Case Study From Vietnam.	Long, N. D., Ogunlana, S., Quang, T., & Lam, K. C.
29	2005	Delays And Cost Increases In The Construction Of Private Residential Projects In Kuwait.	Koushki, P. A., Al-Rashid, K., & Kartam, N.
30	2005	The Relative Impacts Of Selected Practices On Project Cost And Schedule.	Lee, S. H., Thomas, S. R., & Tucker, R. L.
31	2005	Factors Affecting Cost Performance: Evidence From Indian Construction Projects.	Iyer, K. C., & Jha, K. N.
32	2006	Causes Of Delay In Large Construction Projects.	Assaf, S. A., & Al-Hejji, S.
33	2006	Factors Influencing The Construction Time Of Civil Engineering Projects In Malaysia.	Anuar Othman, A., Victor Torrance, J., & Hamid, M. A.
34	2006	Significant Factors Causing Delay In The UAE Construction Industry.	Faridi, A. S., & El-Sayegh, S. M.
35	2006	Corrective Action Recommendation For Project Cost Variance In Construction Material Management	Veronika, A., Riantini, L. S., & Trigunarsyah, B.
36	2006	Delay Mitigation In The Malaysian Construction Industry.	Abdul-Rahman, H., Berawi, M. A., Berawi, A. R., Mohamed, O., Othman, M., & Yahya, I. A.
37	2006	Construction Delays In Hong Kong Civil Engineering Projects	Lo, T. Y., Fung, I. W., & Tung, K. C.
38	2006	Construction Delays And Their Causative Factors In Nigeria.	Aibinu, A. A., & Odeyinka, H. A.

39	2006	Critical Factors Affecting Schedule Performance: Evidence From Indian Construction Projects.	Iyer, K. C., & Jha, K. N.
40	2007	Using Fuzzy Risk Assessment To Rate Cost Overrun Risk In International Construction Projects.	Dikmen, I., Birgonul, M. T., & Han, S.
41	2007	The Evaluation Of The Delays In The Portuguese Construction.	Couto, J. P., & Teixeira, J. C.
42	2007	Cost And Time Control Of Construction Projects In The UK.	Yakubu, O., & Sun, M.
43	2007	Causes And Effects Of Delays In Malaysian Construction Industry.	Sambasivan, M., & Soon, Y. W.
44	2007	The Significant Factors Causing Delay Of Building Construction Projects In Malaysia.	Alaghbari, W. E., Razali A. Kadir, M., Salim, A., & Ernawati.
45	2007	A Quantitative Assessment Of The Cost And Time Impact Of Variation Orders On Construction Projects.	Oladapo, A. A.
46	2007	The Framework For Minimizing Construction Time And Cost Overruns In Padang And Pekanbaru, Indonesia	Harisaweni.
47	2008	Problems Causing Delays In Major Construction Projects In Thailand.	Toor, S. U. R., & Ogunlana, S. O.
48	2008	Causes And Effects Of Cost Overrun On Public Building Construction Projects In Ethiopia	Nega, F.
49	2008	Cost Overrun Factors In Construction Industry Of Pakistan	Azhar, N., Farooqui, R. U., & Ahmed, S. M.
50	2008	Delays In Construction Projects: The Case Of Jordan.	Sweis, G., Sweis, R., Hammad, A. A., & Shboul, A.
51	2008	Causes Of Delay In Building Construction Projects In Egypt.	Abd El-Razek, M. E., Bassioni, H. A., & Mobarak, A. M

52	2008	Delay And Cost Overruns In Vietnam Large Construction Projects: A Comparison With Other Selected Countries.	Le-Hoai, L., Dai Lee, Y., & Lee, J. Y.
53	2008	Conceptual Delay Mitigation Model Using A Project Learning Approach In Practice.	Abdul-Rahman, H., Yahya, I. A., Berawi, M. A., & Wah, L. W.
54	2008	Causes Of Construction Delays Of Apartment Construction Projects: Comparative Analysis Between Vietnam And Korea.	Kim, Y. M., Kim, S. Y., & Luu.
55	2008	Delays In Building Construction Projects In Ghana.	Fugar, F. D., & Agyakwah-Baah, A. B
56	2008	Factors Influencing Time and Cost Overruns in Construction Projects	Al-Najjar, J. M.
57	2009	Causes Of Delay In Construction Industry In Libya.	Tumi, S. A. H., Omran, A., & Pakir, A. H. K.
58	2009	Construction Project Cost Escalation Factors.	Shane, J. S., Molenaar, K. R., Anderson, S., & Schexnayder, C.
59	2009	Cost Escalation And Schedule Delays In Road Construction Projects In Zambia.	Kaliba, C., Muya, M., & Mumba, K.
60	2009	Causes, Effects, Benefits, And Remedies Of Change Orders On Public Construction Projects In Oman.	Alnuaimi, A. S., Taha, R. A., Al Mohsin, M., & Al-Harthi, A. S.
61	2009	Cost And Time Control Of Construction Projects: A Survey Of Contractors And Consultants.	Olawale, Y. A., & Sun, M.
62	2009	Causes Of Delays In Saudi Arabian Public Sector Construction Projects.	Al-Kharashi, A., & Skitmore, M
63	2009	Claims In International Construction Contract: A Case Study Of Ethiopia	Yi, L.
64	2009	Delays And Cost Overruns In The Construction Projects In The Gaza Strip.	Enshassi, A., Al-Najjar, J., & Kumaraswamy, M.
65	2010	Causes Of Delay In The Planning And Design Phases For Construction Projects.	Yang, J. B., & Wei, P. R.

66	2010	Cost And Time Control Of Construction Projects: Inhibiting Factors And Mitigating Measures In Practice.	Olawale, Y. A., & Sun, M.
67	2010	Significant Factors Causing Time And Cost Overruns In Construction Projects In The Gaza Strip: Contractors' Perspective	Enshassi, A., Kumaraswamy, M., & Al-Najjar, J.
68	2010	Evaluation Of Risk Factors Leading To Cost Overrun In Delivery Of Highway Construction Projects.	Creedy, G. D., Skitmore, M., & Wong, J. K.
69	2010	Factors Influencing Time and Cost Overruns In Indian Construction Projects"	Enshassi, A., Kumaraswamy, M., & Al-Najjar, J.
70	2011	Preliminary Study On Causative Factors Leading To Construction Cost Overrun	Memon, A. H., Rahman, I. A., & Azis, A. A. A.
71	2011	Factors Affecting Construction Cost In Mara Large Construction Project	Memon, A. H., Rahman, I. A., Abdullah, M. R., & Azis, A. A. A
72	2011	The Causes And Effects Of Project Delays In The Coal Mining Industry In South Africa	Lee, C.
73	2011	Time Overrun In Construction Projects From The Perspective Of Project Management Consultant (PMC)	Memon, A. H., abdul Rahman, I., & Aziz, A. A. A
74	2011	Problems Of Projects And Effects Of Delays In The Construction Industry Of Pakistan	Haseeb, M., Bibi, A., & Rabbani, W.
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