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EFFECT OF INFORMATION SYSTEMS IN POSTWAR CONSTRUCTION

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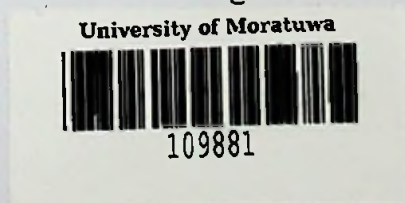
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This Dissertation was submitted to the Department of Civil Engineering
of the University of Moratuwa in partial fulfillment of the requirements
for the Degree of Master of Science in Construction Project

Management.



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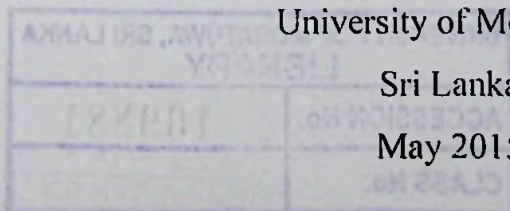
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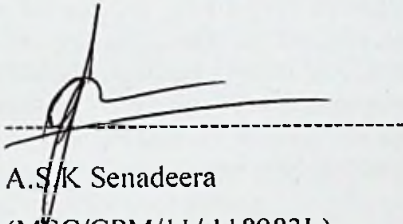
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DECLARATION

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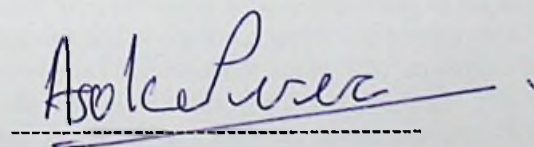


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(MSC/CPM/11/118983L)

Date: 22 May 2015

This is to certify that this thesis submitted by A.S.K Senadeera is a record of the candidate's own work carried out by him, under my supervision. The matter embodied in this dissertation is original and has not been submitted for the award of any other degree.



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Date: 22 May 2015

ABSTRACT

Military Engineering was known to humankind from the Roman era and there after empires were created with ingenuity of military construction projects such as Great Wall of China and Castles in Europe. Reconstruction projects undertaken by the military always follow concepts that specialize in criteria governed by the Militarized theories. Further, Information Technology has helped to bridge the gap of project management tools and techniques to enhance productivity in most effective and efficient manner. Most of the manufacturing oriented organizations in Sri Lanka are shifting towards the modernization and reaping the benefit of Information Technology. The use of Information Technology for specialized projects such as post-war reconstruction projects is considered groundbreaking in the Sri Lankan context. This study will reveal the insights of using Information Technology for Project Management in projects undertaken by the military during the post-war era of Sri Lanka.

The main objective of the research is to analyze productivity improvement and information availability in post-war construction that can be achieved with Information Systems. To achieve the objectives of the research, literature review compiled to identify barriers of construction project management, real impact of IS on performance of project deliverables and major issues in physical infrastructure reconstruction and construction undertaken by military. Literature review begins with war theories and the great events of history, which totally changed the way of human life through civilization. Systematically the study moves into the nature of projects undertaken by the Military. The Project Management aspects in Construction are severely scrutinized to capture the theoretical background of proper Project Management and challenges. It further elaborates the theories which govern the role of Military in post war scenarios including the internal and external forces. On the other hand use of Distributed Information Systems and their benefits were comprehensively reviewed to set the basis for the research.

The methodology derived was two folded. Case study based analysis of a construction project undertaken by the military was the main focal point while the outcomes were strengthened by expert reviews. The data analysis was carried out with the real time data of the selected case which was "Defence Headquarters Complex Project" which is constructed by the defense forces of Sri Lanka. The data captured in to a real Enterprise Resource Planning System with comparisons between manual processes. The industry experts were selected from a pool of professionals considering several key attributes. The analysis was carried out in parallel with the manual processes and professional review. After capturing considerable amount of real time data the outcomes were derived.

The analyzed data were tabulated and compared based on key attributes such as time benefit and information availability under six knowledge areas namely asset, time, cost, reporting, finances and stores management. The conclusion derived from the analysis clearly illustrated that time reduction achieved in all knowledge areas under study is greater than 83.4%. The increase of information depth in managerial and operational levels are greater than 73.3% and 60.8% respectively in all knowledge areas considered for research study. The analysis was meticulous on the basis that the comparison was made real time with exact environment. The conclusions derived from the analysis clearly illustrated the level of efficiency made available with use of Distributed Information Technology Systems and further enhanced with the professional reviews.

Sri Lanka, as a developing nation will be able to reap the benefits of Information Technology with the correct usage and application. Although the Military Construction Projects are considered unique in several aspects, the analysis illustrates that Information Technology can be successfully utilized to enhance the key aspects of Project Management such as Time, Cost and Quality. This study can be further extended to analyze many influential aspects such as human behaviour towards Information Technology Systems and Technological Behaviour in Sri Lanka.

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LIST OF ABBREVIATIONS

BPR	: Business Process Re-engineering
CMU	: Construction Management Unit
CPM	: Construction Project Management
CPI	: Cost Performance Index
EIS	: Executive Information System
ERP	: Enterprise Resource Planning
EVA	: Earned Value Analysis
EVM	: Earn Value Method
GoSL	: Government of Sri Lanka
GRN	: Good Receive Note
HTTP	: Hypertext Transfer Protocol
ICT	: Information and Communication Technology
IS	: Information Systems
IST	: Internet Service Provider
IT	: Information Technology
LTTE	: Liberation Tigers of Tamil Elam
MIS	: Management Information System
MOD	: Ministry of Defense
MRP	: Material Requirement Planning
NATO	: North Atlantic Treaty Organization
OSS	: Open Source Software
PDF	: Portable Document Format
PHP	: Hypertext Processor
PM	: Project Management
PMU	: Project Management Unit
SaaS	: Software as a Service
SAP	: System Application Programme
SCM	: Supply Chain Management
SEM	: Systems Engineering Management
SLA	: Sri Lanka Army
SLAF	: Sri Lanka Air Force
SLN	: Sri Lanka Navy
TPS	: Transaction Processing System
WBIS	: Web Based Information System
USAID	: U.S. Agency for International Development

CHAPTER 1 – INTRODUCTION

1.1 OVERVIEW

Correlation between Information Technology (IT) and postwar reconstruction seem fragmented topics. When two topics merge, it provides invaluable benefit to the construction industry. In general, IT has brought about significant improvements in construction industry and in the entire human life as whole. Most organizations today rely upon IT to enable them to achieve their company or enterprise vision, business strategy and goals.

Further, IT has helped to bridge the gap of Project Management (PM) tools and techniques to enhance productivity in most effective and efficient manner. Most of the manufacturing oriented organizations in Sri Lanka are shifting towards the modernization and reaping the benefit of IT. Other than manufacturing organizations, several other departments in construction industry also have moved on with it, but construction services of military under Ministry of Defence in Sri Lanka are not benefiting the advantage or reaping at least reasonable segment of benefits in terms of communication, coordination and management of projects.

The main purpose of this research is to explore the effect of Information System (IS) in postwar reconstruction and construction. In general, the postwar reconstruction means rebuilding public sector services, which constitute of two types namely reconstruction and stabilization. However, this research focuses on construction and reconstruction of economic infrastructure in postwar scenario, which primarily consists of transportation (road, railways and bridges), energy and utilities (electricity, gas), water supply and sanitation services, telecommunication systems, health services and essential government services. Finally it narrows down to investigate the effect of IS in physical infrastructure reconstruction and construction undertaken by Tri-Services with a view to optimize the performance of construction services of the military of Sri Lanka.

1.2 OBJECTIVE

The main objective of the research is to analyze productivity improvement and information availability in postwar construction that can be achieved with IS. The sub objectives of the main research area are to perform analysis in the areas of

- I. Assets Management
- II. Cost Management
- III. Time Management
- IV. Project Forecast
- V. Project Account and Financial Management
- VI. Purchase and Stores Management

1.3 METHODOLOGY

Proposed methodology for the research involves an extensive literature survey on IS, PM, postwar reconstruction, infrastructure construction and reconstruction undertaken by military of Sri Lanka. To review and analyze the background and benefit of Enterprise Resource Planning (ERP) systems, thorough literature review would be done on evolution, benefits and implementations of ERP systems. Therefore, these are viewed in a broader context of Construction Industry, Information Technology, and PM as illustrated in Figure 1.1.

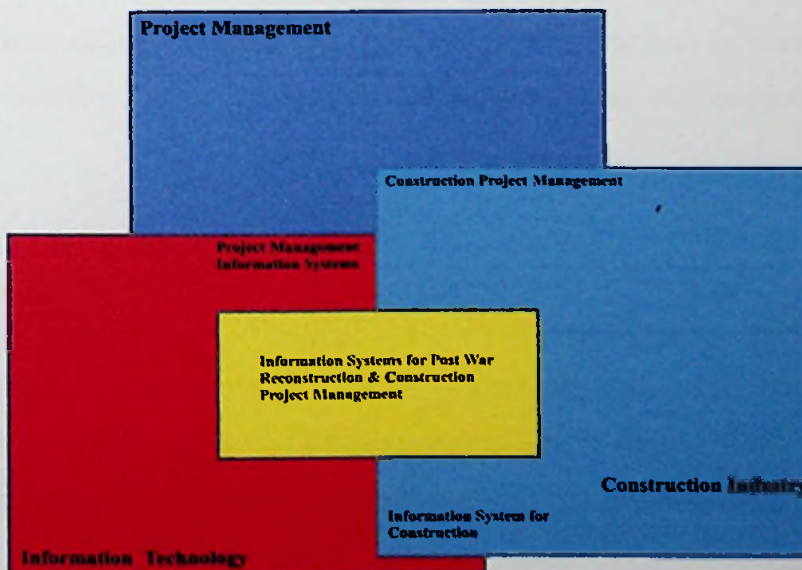


Figure 1.1: Organization of the Research

To review and analyze the background of effect of IS in postwar reconstruction and construction undertaken by military; thorough literature review compiled to identify barriers of construction PM, real impact of IS on performance of project deliverables and major issues in physical infrastructure reconstruction and construction undertaken by military. The literature would give an entry point for this study to further analyze the benefits of IS, especially the effective PM, and its financial benefits.

1.4 PROBLEM RATIONALE

Having successfully completed the post-war reconstructions under "Eastern Revival and Northern Spring" launched by the Government in 2009, military has been entrusted with development projects in various disciplines both public and private infrastructures around the country. The fragmented environment in the construction undertaken by military has a big influence on production. The multi-disciplinary nature of the project development process imposes the need for clear communications and team effort coordination. IT has been playing a tremendous role in facilitating this process in construction industry around the globe.

Therefore, construction units / regiments in military have been compelled to explore all possible options as to how successful product delivery could be achieved in most efficient and effective way. IT is an enabler to facilitate the improvements required for modernization of military construction style. Hence, this research focuses to evaluate the effect of information system in post-war reconstruction and construction under postwar scenario.

1.5 STRUCTURE OF THE THESIS

The chapters in this thesis are structured in way that it presents sequentially as an integral part of the whole dissertation with relevant referencing and linking information. Each chapter highlights the elements of design process, which require fulfilling the aim and objective of the research until completion of acquiring new knowledge.

Chapter 1 provides an introduction to research design with the details of the research namely, background, objectives and importance of the study and the limitations of the work. This chapter provides the background for the study and guidance to read through.

Chapter 2 explores the literature parallel with research design to create approach for scientific investigation of the study. Literature starts from war theories, engineering, comparing the effect to the society, and responsibility of society during war and postwar scenario. It reveals barriers for PM and postwar reconstruction and construction projects in the globe. It further explores degree of impact on transformation of technology of IS and how new technology help enhance productivity and efficiency of Construction Project Management (CPM). Whole process of literature review facilitates continuous knowledge building that is required for the research process.

Chapter 3 critically discusses research paradigms and philosophies, which is an important part of research methodology. Type of research methods practiced by researchers, and most suited research methods for IT related study are discussed under this chapter. Further, it highlights merits and deficiencies of selected research method and how these deficiencies are overcome in scientific manner. It argues on selection of best research methods to investigate impact of IS on postwar reconstruction and construction.

Chapter 4 contains the data analysis and review. The data collected from selected case study are analysed in order to take an insight to the real life problem. Supported by literature, global case studies, and expert's views of the construction industry a comprehensive data analysis is included in this chapter.

Chapter 5 constitute of research conclusion and recommendations. Under conclusion, researcher expresses the benefits that can be achieved after deployment of ERP system to the project considered for case study under six subject groups. Outcome of the research analyzed under two scenarios; benefit of time and information availability to project team members is presented here. It identifies further research scope emanating from the research conducted. Future research is included in this chapter to show that what areas of research are to be conducted to enhance the validity of research outcome.

CHAPTER 2 - LITERATURE REVIEW

2.1 OVERVIEW

This chapter presents the role of IS in post-war reconstruction and construction while narrating the literatures of researches done up to date. Literature Review focuses on post-war scenario, reconstruction, PM, IS for CPM and projects undertaken by military. Finally, these topics are integrated and narrowed down to postwar reconstruction and construction PM. The literature review provides the basis of knowledge to move forward with the research study. Prior to define post-war scenario it is more appropriate to start with the definition of real meaning of "war".

2.2 WAR THEORIES AND MILITARY ENGINEERING

2.2.1 Overview

This chapter describes the theories of war from the originality and how just war theory emerged to justify reason to begin a war and equally apply the rules of war to all concerned. Just war theory divides into three parts

- I. jus ad bellum – the justice of resorting to war;
- II. jus in bello – just conduct in war
- III. jus post bellum – justice at the end of war.

It further illustrates relationship between military engineering and civil engineering. Military engineering refers to performance of designing, building, maintaining and dismantling military works, including offensive, defensive and logistical structures, to shape the physical operating environment in war (Harp, 2011).

2.2.2 Theories of War

Humankind was originally peaceful but fell into war as human society passed into new phases of history, and war between humankind roused in stages, from armed raids to a political expression of early nationalism. Wars continued with the ownership of land, the rise of towns, and with authoritarian kings. Kings wanted more power and possessions

without concern other factors or from whom they would get it. War had beginnings that were not necessarily linked to a previous war

War is an organized, armed, and often a prolonged conflict that is carried on between states, nations, or other parties. War should be understood as an actual, intentional, and widespread-armed conflict between political communities. It is therefore defined as a form of political violence (D'Amato, 2013).

The set of techniques used by a group to carry out war is known as warfare. An absence of war (and other violence) is usually called peace. Meantime wars can be classified according to its nature of incident as Civil Wars, Guerrilla Wars, Wars Of Independence, Invasions, Religion-Based Wars, Wars Of Succession, Insurgency, Class or Caste War, Cold War and so on. The period of war also depends on complexity of the problem and the capabilities, tactics used by the actors involved in war (D'Amato, 2013).

Some philosophers argue that war should always be the last resort. Just war theory emerged to justify reason to begin a war equally apply the rules of war to all. The just war tradition is divided into three sets of principles: *jus ad bellum* describes how entity should resort to war, *jus in bello* prescribes how soldiers should fight in war and *jus post bellum* delineates the rights and duties of belligerents to react one another once the war is over (Harp, 2011).

Jus ad bellum (the right to go to war):

Just cause: The reason for going to war needs to be just and cannot therefore be solely for recapturing things taken or punishing people who have done wrong. The just causes most frequently mentioned include self-defence from external attack, the defence of others from such actions, the protection of innocents from brutal, aggressive regimes and intervention to protect life of innocent life.

Comparative justice: While there may be rights and wrongs on all sides of a conflict, to overcome the presumption against the use of force, the injustice suffered by one party must significantly outweigh that suffered by the other.



Competent authority: Only duly constituted public authorities may wage war. "A just war must be initiated by a political authority within a political system that allows distinctions of justice. Dictatorships (e.g. Hitler's Regime) or deceptive military actions (e.g. the 1968 US bombing of Cambodia) are typically considered as violations of this criterion.

Right intention: Force may be used only in a truly just cause and solely for that purpose, while material gain or maintaining economies is not.

Probability of success: Arms may not be used in a futile cause or in a case where disproportionate measures are required to achieve success.

Last resort: Force may be used only after all peaceful and viable alternatives have been seriously tried and exhausted or are clearly not practical.

Proportionality: The anticipated benefits of waging a war must be proportionate to its expected evils or harms (Harp, 2011).

Jus in bello (right conduct within war):

Once war has begun just war theory (Jus in bellum) also directs how combatants are to act or should act.

Distinction: Just war conduct should be governed by the principle of distinction. The acts of war should be directed towards enemy combatants, and not towards non-combatants caught in circumstances they did not create. The prohibited acts include bombing civilian residential areas that include no military target and committing acts of terrorism or reprisal against civilians.

Proportionality: Just war conduct should be governed by the principle of proportionality. An attack cannot be launched on a military objective in the knowledge that the incidental civilian injuries would be clearly excessive in relation to the anticipated military advantage (principle of proportionality).

Military necessity: Just war conduct should be governed by the principle of minimum force. An attack or action must be intended to help in the military defeat of the enemy.

Fair treatment of prisoners of war: Enemy soldiers who surrendered or who are captured no longer pose a threat. It is therefore wrong to torture them or otherwise mistreat them (Fichtelberg, 2006).

Jus post bellum (Ending a war):

Just cause for termination: A state may terminate a war if there has been a reasonable vindication of the rights that were violated in the first place.

Right intention: A state must only terminate a war under the conditions agreed upon in the above criteria. Revenge is not permitted. The victor state must also be willing to apply the same level of objectivity and investigation into any war crimes its armed forces may have committed.

Public declaration and authority: The terms of peace must be made by a legitimate authority and must be accepted by a legitimate authority.

Discrimination: The victor state is to differentiate between political and military leaders, and combatants and civilians. Punitive measures are to be limited to those directly responsible for the conflict. Truth and reconciliation may sometimes be more important than punishing war crimes (Englewood, 1989), (Harp, 2011), (Fichtelberg, 2006).

2.2.3 Military Engineering vs. Civil Engineering.

It is believed that humankind existed for tens of thousands of years formed in small groups. These societies transformed through different living patterns starting from hunter gathering to agrarian and finally to an industrial society. The exact origin of the word 'engineering' comes from the era when humans applied themselves to skillful inventions (Smith R. , 2012). The original meaning of the word engineer was one who constructs military engines. It is an accepted belief that the first engineers were military engineers, employed by the State or Empire, who concerned themselves with subjects such as roads, bridges, and fortifications. Military Engineering is known as designing of structures or assemblies required for military warfare and military operations. Roman army is the very good example in medieval time. When the Romans expanded their Empire in the Western World, roads and infrastructure were built in every location they acquired and occupied.

It made possible to keep the soldiers occupied and out of trouble as they were away from homes. Much of the work of military engineers focuses on keeping troops safe on battlefields and in war zones. This requires building safe structures to house soldiers and equipment, as well as space required for administrative work, training and vehicles. These facilities must be functional as well as secure. Those designs should be capable to face various threat perceptions using materials at hand. Military engineering also incorporates earthwork, including the design and construction of trenches, embankments, and other structures (Parrott, 2010).

Followings are the great events of history, which totally changed the way of human life through civilization.

- I. Food production revolution (6000 - 3000 B.C)
- II. Appearance of urban society (3000 - 2000 B.C)
- III. Birth of Greek science (600 - 300 B.C)
- IV. Revolution in power (middle ages)
- V. Rise of modern science (seventeenth century)
- VI. Steam and Industrial Revolution (eighteenth century)
- VII. Electrical and beginning of applied science (nineteenth century)
- VIII. Age of automatic control (twentieth century)

Nomadic people hunt for their living or gather fruits and vegetables. Humans devised fundamental inventions such as the pulley, lever, and wheel sometimes around 6000 B.C. Man started to tame animals and cultivates plants, which was a great development in the human history. They started to produce foods for their living approximately between 6000 B.C - 3000 B.C (Kirby, Withingtn, Darling, & Kilgour, 1990).

Rise of cities was the significant change occurred in human living sometime before 3000 and developed further from 3000 B.C to 2000 B.C. In line with these developments, purely empirical engineering knowledge also built up through experience and that knowledge handed over from person to person. It was with the urban revolution that political, social, cultural, economic, and religious factors motivated and paved the way for development of engineering disciplines especially in the field of roads, irrigation.

aqueducts, and sea transportations. History of Ancient Mesopotamia has contributed much for modern civilization. The first forms of writing came from them in the form of pictographs around 3100 BC. (Kirby, Withingtn, Darling, & Kilgour, 1990).

Origin of science is traditionally ascribed to Greek philosophers whose approach to think about nature was the greatest breakthrough in human history, which started around 600 B.C. Before Greek civilization emerged in 600 B.C, Egyptian and other people like Mesopotamians had created great scientific evolutions, which helped not only for Greek to move forward but also for modern technological innovations and creations (Deming, 1954).

Greek achievements in science during 600 B.C to 300 B.C lead to dramatic development in engineering. The entire knowledge gained before six century B.C was through the human experience and there were no theories of natural phenomenon or of mathematics. Greatest glory should go to Greek for discovering general laws in nature. They started to investigate the problem of matter and probe to think what it is that all are made (Deming, 1954). Despite, Greek learned and gathered knowledge from Egyptians analytical thinking and scientific investigation of nature helped them to establish firm theories of science and mathematics(Deming, 1954).

For 500 years from 21 B.C to 476 A.D the strongest Empire world ever had seen was the Roman Empire. The Romans were some of the greatest conquerors of the ancient world. It is believed roads markers showed the distance to Rome even from more than thousand miles distance. More than the roads connected to Rome, 50 million people bind together from Roman law, Roman custom and Roman military. Rome is an ideal place for a city. It is located along the banks of the Tiber River. The river made it easy to travel to and from the sea (Mark, Goodman, & Price, 1999). Romans are very famous for advanced constructions and they used lot of public projects to make the city more advance of the ancient world. The buildings and architecture of Ancient Rome were impressive even by modern standards. Many of the roads, bridges and aqueducts of ancient Rome are still used today. Roman put great effort into engineering which used as a way of improving the lifestyle of Romans (Deming, 1954).

Roman engineering as well as Roman military engineering constituted a large portion of Rome's technological superiority and legacy. The construction of hundreds of roads, bridges, aqueducts, baths, theaters and arenas are remarkable feats of Engineering in Roman era. Many monuments as the Colosseum, Pont du Gard, and Pantheon, remain as testaments to Roman engineering and culture. The Romans used the ideas of the Ancient Greeks to implement their own engineering plans. In the 1st century BC, Romans started to use concrete widely for their constructions, which had been invented in the late 3rd century BC. It was powerful cement derived from pozzolana, and soon it was replaced by marble as the chief Roman building material (Mark, Goodman, & Price, 1999).

Concrete made possible the paved, durable Roman roads, many of which are still in use a thousand years after the fall of Rome. One of the most notable examples of military bridge building in the Roman Empire was Julius Caesar's Bridge over the Rhine River. This bridge construction completed within ten days and is estimated to be more than 100m long. The construction of a vast and efficient travel network throughout the Empire dramatically increased Rome's power and influence. Sophisticated travel network made possible Roman Empire to deploy Roman legions / troops (Mark, Goodman, & Price, 1999).

The whole issue of supplying Rome with water was solved using a system of centuries of kilometers of aqueducts. Numerous aqueducts constructed to supply water to cities, industrial sites and to assist in their agriculture. Eleven aqueducts with a combined length of 350 kilometers supplied the city of Rome. Most aqueducts were constructed below the surface, with only small portions above ground supported by arches. Sometimes, inverted siphons were used to force water uphill, where depressions of aqueduct deeper. The Romans also made major advancements in sanitation. Romans were particularly famous for their public baths, which were used for both hygienic and social purposes. Many Roman houses had flush toilets, indoor plumbing network, and a complex sewer system (Mark, Goodman, & Price, 1999).

Success of military operation in ancient wars brought through highly valued customs and sophisticated supply chain management. Roman succeeded expanding their territory or conquering states through their military culture, their weapons and their training. When

Roman loses a battle entire troops or part of the fleet were replaced and uninterrupted supply of men and provisions driven Roman war success. The leaders never start operations until completion of their logistical preparations. When a war broke out unexpectedly, hustle logistic preparations had to be done. However, their experience gained by frequent encounters with enemies for conquering helped them for impromptu arrangement of provisions and men. Romans manage to deliver provisions to frontiers by variety of ways: by sea and river, overland while avoiding risk of foraging. The Army provided escort to military cargo even during peacetime. The use of fortified depot considerably reduced the risk of attack to supply line. Protecting of own supply line was an important element of ancient warfare as lack of supplies could cripple capacity of troops in a relatively short period (Roth, 1999).

Middle age or medieval time believed to have started with the fall of Roman Empire in 476 and lasted until about 1450 or 1500. Great civilization of Roman and Greece has been conquered during that period and hence medieval time is termed Dark Age. However, medieval society contributed much for modern technology. They formed the basis of all industrial skills. Agricultural innovations such as plough helped increase production capacity of cultivation. Specialist type water mill termed tide mill driven by rise and fall of tide was another innovation around 787 A.D. Hour glass in 9th century blast furnace, liquor in 12th century, Eye Glasses, Medical Clock, Spinning Wheel in 13th century, Printing Press in 15th century are few dramatic inventions during medieval time (Listverse, 2007); (Alchin, 2012)

Seventeenth century was the period where changes in philosophy and science helped to begin modern era of science. During the 17th century, the science of chemistry developed from medieval alchemy, and the 17th century science of astronomy evolved from astrology. This is the era science had become an established mathematical, mechanical, and empirical body of knowledge (Bellis, 2012).. At the dawn of 17th century, Middle East and North Africa were divided between two major Empires, Safavid Empire of Persia and Ottoman Empire of Turkey. Ottoman Empire added more territory spanning towards Eastern Europe, Egypt and North Africa and reached to its highest position at the

beginning of 17th century. Later Ottoman Empire declined as it failed to keep up with the technological advances in Europe (Chary, 2007).

This is the era Copernicus, Kepler, and Galileo started the process in astronomy. Galileo and Kepler also began developing mathematical physics and were important predecessors of Newton. Kepler, Galileo and Newton showed the power of mathematics in describing the behaviour of the physical world.

The Industrial Revolution is one of the most celebrated turning points in human history. The 18th century does represent a decisive break in the history of technology and the economy. The famous inventions—the spinning jenny, the steam engine, coke melting, and so forth—deserve their renown. The industrial revolution started in Britain with the inventions that created factory textile production, the shift to coal and coke in the iron industry, and the perfection of the steam engine. Economic growth on the continent occurred when these innovations were adopted there (Allen, 2006).

The 19th century witnessed the rise of modern industry. From Western Europe to Britain to North America, agriculture lost its dominant role in societal reproduction and yielded to industrial manufacturing and technology-intensive services like railroads, steam navigation, and telecommunication. Dramatic changes in the social fabric and the face of landscapes spread from the North Atlantic region throughout the world and bore witness to a fundamental shift in human history. Both the number of people and artifacts grew at an unprecedented rhythm. This emerging modern world was driven by an unending stream of new products turned out by factories employing radically new technologies, skills, and organization. Technological innovations, being the most tangible results of this new, accelerated mode of reproduction, were soon understood to represent the rationale of nascent industrial society (Oyekan, 2003).

The 20th century has witnessed an explosive growth in science and technology. New inventions including spaceships, computer chips, lasers, and recombinant DNA have opened pathways to new fields such as space science, biotechnology; and nanotechnology. Modern seismographs and submarines have given earth and ocean scientists insights into the planet's deepest and darkest secrets. Decades of weather



science, aided by satellite observations and computer modeling, now produce long-term, global forecasts with high probabilities of being correct. At the start of the century, science and technology had little impact on the daily lives of most people. This had changed radically by the year 2000(Arbe, Mittelstrass, & Sorondo, 2010).

2.3 POSTWAR SCENARIO

2.3.1 Overview

Postwar period is the interval immediately following the ending of a war and continuing as long as war does not resume. A post-war period can become an interwar period or inter-bellum when a war between the same parties resumes later. Activities normally include managing the transition from relief to economic recovery and longer-term development, return of refugees and displaced persons, security sector reform, reconstructing social and economic infrastructure, rebuilding political institutions for democratic rule and promoting human rights and accountability for past violations in a system of transitional justice (Dibeh, 2005).

This chapter describes socioeconomic status of post-war. The wars are very hazardous and consequences faced by the society during and aftermath of war hampering socioeconomic developments are

- I. Loss of human resources through deaths casualties and migration
- II. Destruction of infrastructure of economy, mainly the electricity, telephone, water and road networks
- III. Negative productivity shock leading to massive redistribution of income, weakening of state institutions including the military, security forces, administrative capacities and especially revenue generating capabilities and resource
- IV. Destruction made to communities through displacement of population mobilization (Dibeh, 2005).

It further describes agony of war and few incidents faced by the societies lived in war zone areas to show effect on socioeconomic state during a tragedy.

The Second World War was one of the major disastrous events of the 20th century. The Korean War which lasted from 25 June 1950 to 27 July 1953 was a war between the Republic of Korea supported primarily by the United States of America, with contributions from allied nations under the aegis of the United Nations and the Democratic People's Republic of Korea supported by the People's Republic of China. El Salvador, Central American country bordered by Honduras, Guatemala and Pacific Ocean also experienced the agony of civil war between rich and poor due to longstanding socioeconomic inequality, which existed more than a century. El Salvador, Central American country bordered by Honduras, Guatemala and Pacific Ocean also experienced the agony of civil war between rich and poor due to longstanding socioeconomic inequality (Long & Eichengreen, 1991).

It further describes military role. Military is playing a gigantic role in uplifting broke down societies and socioeconomic status going beyond its primary role of fighting with enemy. Military involves in post-conflict operations, known as "occupations", reconciliation and reconstruction of polarized state or opposing groups.

Postwar scenario creates state's instability leading to governance void and making it difficult to reconstruct the state or rebuild sustainable peace. Reconstruction cannot therefore be a reconstitution of the state in its pre-conflict form. Donors need to engage with different layers of political authority above and below the state as well as rebuild central government. Therefore, development of war-torn societies is impracticable without the involvement of international community (Long & Eichengreen, 1991).

2.3.2 Socio Economic Status in Postwar Scenario

History reveals that the consequences of war are so momentous that they often mark the division between historical eras. The devastation of war also creates a need for rebuilding and establishment of new political systems designed to restore social stability and to recover lost prosperity. At the same time, war does not wipe everything away; social and political organizations are remade based on pre-war influences while adapting to a new social and political equilibrium (Snyder & Lee, 2010).

Marshall (2001) stresses that socioeconomic status can be evaluated as factors including income, level of education, etc. It is a measure to look at how individuals or families fit into society using economic and social measures, which will, reflects individuals' health, well-being, occupation, social status, lifestyle choices etc. which associates with both finances and education. Every war in almost all the cases had a grave impact on socioeconomic status. Marshall (2001) illustrates the followings factors as major concerns among the social effects resulted by war (Marshall, 2001).

Human Resources: Loss of human resource are from direct deaths (combatant and non-combatant); indirect deaths (from collateral fire, induced-famines and droughts, epidemics, medical shortages); direct injuries (physical and psychological, permanent and temporary); indirect injuries (crime and victimization, experiential trauma, grief, diminished health and capabilities, increased insecurity); sexual crimes and intimidation (rape, prostitution, child molestation, gender domination).

Population Dislocations: Loss of population associated with the displacement, whether for personal-safety, logistic, predatory, retaliatory, or strategic policy considerations, of large numbers of domiciled people, either within the parameters of the affected society (internally displaced, forcibly relocated, or sequestered persons) or across societal borders (e.g., refugees, asylum-seekers, emigrants) (Marshall, 2001)..

Societal Networks: Damage and distortions to the fragile fabric of inter-personal associations and the disintegration of relationships and identities based on amity, trust, exchange, mutual benefit, comity, reciprocity, and deferred gratification, relations necessary for the proper and effective functioning of normative systems (social cooperation, cohesion, coherence, and coordination in politico-legal, economic, professional, and socio-cultural sub-systems).

Environmental Quality: Direct and indirect damage and destruction to general ecosystem: use or release of explosive, corrosive, and de-vegetative chemical compounds and mechanical devices that limit utilization of agricultural resources, foul surface and subterranean water resources, pollute atmosphere, disseminate toxic substances and hidden explosive devices, and destroy wildlife and habitats (Marshall, 2001)..

Infrastructure Damage and Resource Diversions: Loss due to direct damage, destruction, and overconsumption of material and mechanical infrastructure, resources, and surpluses such as production facilities, storage, transport networks, vehicles, water supplies, croplands, food, medical supplies, etc.

Diminished Quality of Life and Non-reciprocal Resource Transfers: Tangible and intangible losses (both short- and long-term) associated with general deteriorations in the immediate, aesthetic quality of life, access to basic needs, and future prospects in affected societies; humanitarian crises; capital outflows (Marshall, 2001).

Few incidents faced by the people lived in war zone areas are mentioned to show effect on socioeconomic state during a tragedy. The Second World War was one of the major disastrous events of the 20th century, with 29 million deaths in Europe alone. It involved a vast majority of the world's nations including all of the great powers forming in to two oppositions military alliances, the Allies and the Axis. Heavy losses to physical damages occurred through six years of constant ground battle and heavy bombing. Many including young children witnessed the horror of war and crimes against humanity that horrendous war took place. The war forced people to abandon their property without compensation while falling people into starvation (Kesternich, Siflinger, Smith, & Winter, 2012).

The Korean War which lasted from 25 June 1950 to 27 July 1953 was a war between the Republic of Korea supported primarily by the United States of America, with contributions from allied nations under the aegis of the United Nations and the Democratic People's Republic of Korea supported by the People's Republic of China. After the war, North Korea had to start from the ground up because of three years of the U.S. bombing attacks that had devastated the country's physical infrastructure. North Korea also suffered a tremendous loss of human capital, losing almost 1 million or more than 10 percent of its people, through either war or exit by refugees who resettled in South Korea or outside the Korean peninsula (Snyder & Lee, 2010).

El Salvador, Central American country bordered by Honduras, Guatemala and Pacific Ocean also experienced the agony of civil war between rich and poor due to longstanding

socioeconomic inequality, which existed more than a century. The fully-fledged official outbreak of the civil war lasted for little more than twelve years from October 1979 to January 1992 between the military-led governments of El Salvador, which was backed politically, economically and militarily, by the United States government. The two primary actors in the El Salvador civil war were a Marxist-Leninist guerrilla group, called the Farabundo Martí National Liberation Front, and the government of El Salvador (Allison, 2012). Peace accord negotiated in 1992 brought conflict between leftist, Farabundo Martí National Liberation Front, and the government of El Salvador towards the end of 12 years insurgency (CRSweb, 2005).

World Bank News and Views October 12, 2012 stresses despite gaining social and economic development in Central America continuation of high crime and violence has become a heavy social burden. In addition to the problems of crime, limited job opportunities and deficit of employment opportunities create vicious cycle of unemployment and low wages especially among young people (WorldBank, 2012). Throughout Central America, underlying social conditions and structural weaknesses in governance inhibit efforts to improve security. Persistent poverty, inequality, and unemployment leave large portions of the population susceptible to crime (Meyer & Silke, 2012).

2.3.3 Military Role in Postwar

A military is an organization authorized by greater society or by own state and authorized by law to use lethal force, usually including use of weapons, in defending its country by combating actual or perceived threats and if threats manifest, fight and winning the national wars to safeguard the country. Deter internal aggression and if deterrent fails and aggression take place fight or use military force and defeat internal aggression in support of civil authorities (Buckeye, 2010).

Another role of military in post-war situation is to get involved in post-conflict operations, known as “occupations”. Sometimes it has been termed as “peacekeeping” or “peace enforcement”. However, current U.S administration has used the terms “stabilization and reconstruction” to refer to its post-conflict operations in Afghanistan

and Iraq. Analysts such as James Dobbins cloud the issue further by defining the term nation building “as actions taken in the aftermath of a conflict to rebuild a nation and support an enduring peace” and place the military in a primary role for nation building, though the term does not appear in military doctrine (Bullimore, 2006).

Humanitarian aid operation by military involvement is not a new phenomenon. Such instances have occurred since before the time of Alexander the Great and have continued through the Napoleonic Wars, the World Wars of the Twentieth Century (particularly the Second World War and the devising of the Marshall Plan) up until the present day. It seems that when disasters, either natural or man-made occur, governments often turn to the military for help as the military have certain resources immediately to hand, such as food, medicine and fuel as well as transport and human assets (Kern, 2011).

Recent operations demonstrate the military's expertise, capabilities, resources, and willingness to conduct post conflict immediate operations effectively and efficiently. Since no other agency or organization can provide the robust security required for post-conflict operations, all military forces have key roles in supporting peace building (Buckeye, 2010). However United State of American War College (USAWC) strategy research project highlighted that in April 2003 that the US lead Coalition Forces took control of Iraq and the military's tasks shifted to postwar security, peacekeeping, and reconstruction. In three years following the invasion of Iraq and subsequent declaration of combat operations, the United State continued with the task of rebuilding Iraq. It was identified the need for a closer relationship between civilian and military leadership on the same mission, implementation of post conflict reconstruction plan and necessity to expand role of military in local governance and capacity building. The post- conflict operation in Iraq represented a new approach to nation building by bringing military and civilian efforts together under one military command. It has been recommended that military being a department having tremendous capacity to accomplish many of the task required for effective post combat stabilization and reconstruction operations to redesign military doctrine comparable to current combat efficiency (Bullimore, 2006); (Svard, 2009)

Apart from above, military involves heavily in reconciliation and reconstruction of polarized state or opposing groups. The fundamental condition for a society to reconcile

is the desire for and commitment to reconciliation among opposing groups. However, a paper by school of advanced military studies argues that military does not possess the organizational capabilities or doctrine to effectively execute a reconciliation process alone. The military role in reconciliation would remain primarily a security one could more effectively support civilian facilitators of a reconciliation process. (Kelly, 2011)

The monograph published by School of Advanced Military Studies (SAMS) emphasizes that military involvement in a reconciliation process is lot more than its doctrinally prescribed role of security and application of military power to coerce opposing parties to reconcile will be ineffective, unsuccessful, and contradictory to the foundational principles of reconciliation. There should be an interaction between military and civilian organization to make the reconciliation successful. The monograph emphasizes civilian and military leaders to promote a greater understanding of reconciliation for their policy makers and doctrine writers and recommend keeping the military role in reconciliation primarily for security thereby military staffs could more effectively support civilian facilitators of a reconciliation process (Buckeye, 2010).

2.3.4 International Community

Intervention of international community will be very important in case of war or disaster situation. International cooperation is common and emergent organizations often arise in the wake of disasters. Global community quickly responds and provides assistance in various ways. The international community moved to enforcement of internal state disputes that is not only a general threat to the international community, international economics or international military but also issues of human security (Svard, 2009).

In Postwar situation the country itself could not be politically and economically strong enough to steer themselves to development process with own resources. At the end of war, country's economy drastically goes down and faces severe social and financial instability. Therefore, private investment to uplift living standard of people and public investment to develop public properties like bridges, roads hospital, ports and other public infrastructures should be the prime target while encouraging foreign investments through international relations. This was satisfactorily done in post-world war II through

Marshal Plan. The main aim of the Marshal Plan was reconstruction of the economies and politics (Long & Eichengreen, 1991).

There are plenty of occasion international community involvements to resolve problems during conflicts or reconstruction of state or country in postwar situations. Just after World War II in 1945, it was a big challenge to victorious allies how to establish a long-enduring mechanism to guarantee international security and peace. As a result, United Nation Organization came up in 1945 to safeguard international security and peace. The North Atlantic Treaty Organization(NATO) or also called the (North) Atlantic Alliance, is an intergovernmental military alliance based on the North Atlantic Treaty which was signed on 4th April 1949. The organization constitutes a system of collective defence whereby its member states agree to mutual defence in response to an attack by any external party (Svard, 2009). Bradford De Long and Barry Eichengreen stresses many international relations success factor of development of social and economic state in half of Europe not occupied by the Red of World War II was the successful establishment of stable market-oriented “mixed economies” through Marshal Plan (Long & Eichengreen, 1991).

In the case of Sierra Leone Civil War (1991- 2002) which end up in peace agreement in 2002 called Lome Peace Agreement between the Government of Sierra Leone and the now defunct Revolutionary United Front. The government of Sierra Leone and the international community has been involved in peace building activities and national reconciliation and reconstruction. The reconciliatory process necessitated the setting up of a Truth and Reconciliation Commission that was also a product of the Lome Peace Agreement (Svard, 2009).

Outbreak of Rwanda war on October 1, 1990 with fifty Rwandan Patriotic Front rebels deserted their posts and crossed the border from Uganda into Rwanda, killing a customs guard at the Kagitumba border post. The offensive failed after France and Zaire militarily intervened. Zaire sent several hundred troops of the elite Special Presidential Division to fight alongside Rwandan government troops. Rwandan Patriotic Front reorganizes as Guerrilla warfare and continues as civil war for couple of years. In May 1995, a team from the Center for Development Information and Evaluation of the U.S. Agency for

International Development (USAID) visited Rwanda for a firsthand assessment of international assistance to that country in the wake of the civil war. The international community directed efforts largely at saving lives by providing food, shelter, and medical and sanitary services to refugees and internally displaced persons. United States through USAID has been the main actor assisting postwar reconstruction in socioeconomic aspects by promoting human rights and building a fair judicial system, support to the economic sector, rehabilitating health and assistance to vulnerable groups and initiatives for healing (Kumar, Tardif-Douglin, Knapp, Maynard, Manikas, & Sheckler, 1996).

In addition to war scenario, international mediation is of vital importance in case of disasters risk arising from hazards interacts with physical, social, economic and environmental vulnerabilities. Events of hydro meteorological origin constitute the large majority of disasters (UN, 2005). On 26th December 2004, coastal areas of countries around the Indian Ocean, including Sri Lanka were hit by a tsunami, caused by an earthquake off the coast of the Indonesian island of Sumatra. The tsunami killed over 200,000 people in Asia and Africa, over 30,000 in Sri Lanka alone. It destroyed homes and buildings, roads, railways and other infrastructure facilities. Millions of people who were not directly affected by the tsunami found themselves without food and health care because of the breakdown in infrastructure (Moonesinghe, 2005).

International mediation is significant for reconciliation, reconstruction of social and economic infrastructures. Reconstruction in Sierra Leone focused most directly on the immediate needs for disarmament and demobilization of former combatants. The large-scale disarmament, demobilization and reintegration (DDR) effort in Sierra Leone has been cited as a United Nations success story. Appearances can be deceiving, however, time has revealed the ineffectiveness of reintegration. The agricultural sector provides three-fourths of the jobs in Sierra Leone, yet DDR programs trained former combatants as plumbers, carpenters, or mechanics. Donors did hope that ex-combatants would settle as farmers, but the reintegration programs they provided did not meet the requirements that would have made this possible (Svard, 2009).

2.4 RECONSTRUCTION

2.4.1 Overview

Construction is a professional discipline that interferes with the designing, planning, construction, and management. The dictionary meaning of reconstruction is the process of building or creating something again that has been damaged or destroyed. However, in this chapter reconstruction refers to rebuilding physical, mental, socio-economic, political and cultural state of the affected area after a serious disruption of the functioning of society caused widespread human, material or environmental losses. This disruption will result from extreme weather events such as floods, cyclones, tornadoes, blizzards, droughts), events related to extremes of the earth's geology (earthquakes, volcanic eruptions) etc. (Etzioni, 2007).

In addition to above, great damage roots to manmade disasters. There are different types of manmade disasters, which are also known as anthropogenic disasters. The anthropogenic disasters caused due to human intention, error or as a result of failed systems. Therefore, terrorism can also be defined as a manmade disaster, which causes huge loss to the nation (Etzioni, 2007).

It has been identified two main causes to motivate a person for terrorism. First reason is social and political injustice to a group of people and second is people's belief that violence or its threat will be effective to resolve issues (Queensland, 2012).

Recovering from a disaster is usually a gradual process. Safety is a primary issue. If assistance is available, knowing how to access it makes the process faster and less stressful. Social, economic and political recovery after war is a cost and time-consuming process. The policy objectives in a post-war economy would be to restore and maintain peace, improve security, prevent the renewal of war, facilitate socioeconomic recovery, and start to build the institutional framework favorable to development and sustained poverty reduction. Socio-economic recovery and poverty reduction are important elements of building peace while improving peace and security reinforce economic growth (Etzioni, 2007).

2.4.2 Reconstruction

Reconstruction is a vast topic, both theoretically and historically and it covers very broad area. Journal of Intervention and State Building states that most scholars, public intellectuals, and those in the media use the term reconstruction equating it with economic development, at least by implication. Some use it even more broadly to refer to general development including democratization and the formation of civil society. It is preferable to define reconstruction much more narrowly in line with the research topic under study. Therefore, reconstruction is defined as the restoration of the condition of the assets and infrastructure of an occupied nation or territory to the same or similar states as it was in before the outbreak of hostilities. It further explains that after Second World War reconstruction has occurred in broad dimensions. It is being done in Iraq and Afghanistan while Economic development has been achieved by nations acting on their own initiative, such as China, South Korea, Singapore and Taiwan (Etzioni, 2007). Therefore, requirement of reconstruction arises in postwar situation just after peace agreement or defeating the internal or external threat to a state as well as post disaster situation, which results from natural threats such as earthquakes, storms, hurricanes, intense precipitations, droughts, heat waves, cold spells, and thunderstorms and lightning (Perry & Quarantelli, 2005).

Reconstruction in postwar scenario rounds up in following issue areas, or “pillars”

Rebuilding institutions, systems, structures and other capacities for service delivery: This may include provision of emergency relief, displaced persons protection, maintenance and resettlement, restoration of essential services and peace enforcement. Overall security may be taken over by an outside organization and it is to be turned over to legitimate national authorities at the earliest possible time.

Economic revitalization: This is revamping of macro-economic structure to support the delivery of the key public services to mitigate inflation and restoring the legal and institutional framework for financial management, recreating and upgrading essential public service staff and institutions, and resuming financial procedures.

Security; This addresses all aspects of public safety, establishment of a safe and secure environment and development of legitimate and stable security institutions. It includes securing the lives of civilians from eminent threats arising from immediate and large-scale violence thus restoring of territorial integrity.

Democratization and social reconciliation; This is to foster cooperation in the divided region and to promote democratic values and reconciliation.

Reconfiguring public administration for sustainable reconstruction; No progress can be made in promoting peace, development and protection of human rights unless appropriate governance and public administration institutions are established

The reciprocal relationship between governance and conflict; Good governance is viewed as how society organizes itself to ensure equity, justice and equal access to opportunity for all citizens and it helps to minimize conflicts (Sundaram, 2010); (Bertucci, 2003).

Scholars have identified and defined deferent methodologies to undertake reconstructions to deliver maximum benefit to the affected society. Etzioni (2007) stresses that Reconstruction would greatly benefit if the concept of triage are applied to it which rely on prioritization by identifying resource limitations. Triage is employed when a disaster causes a large number of casualties and the responders lack sufficient numbers and resources to treat them all simultaneously. Those who rush to assist must decide who is to be helped first, which victims can fend on their own at least for a while. Trying to help everyone at the same time and in the same way is unwise. It further argues that in order to reconstruction to be more effective triage is essential, whereas a scattergun approach is likely to be ineffective (Etzioni, 2007).

Reconstruction covers very broad area, which includes infrastructure as well. The meaning of infrastructure differs from discipline to discipline. It is generally the structural elements, which provide framework to support an entire structure. Infrastructure appears in many forms as economic infrastructure, social infrastructure, IT infrastructure etc. Economic infrastructure means elements of an economy, which allows for production of goods and services. Economically infrastructure could be seen to be the

structural elements of an economy. Economic infrastructure primarily consists of transportation (road, railways and bridges), energy and utilities (electricity, gas), water supply and sanitation services, telecommunication systems, health services and essential government services whereas Social infrastructure viewed as health, education, safety nets etc. The economic infrastructure comes to the society as an output of the construction industry. The infrastructure of a country is part and parcel of the construction industry (Palliyaguru, Amaratunga, & Haigh, 2007).

Natural disasters destroyed critical infrastructures. Post-disaster reconstruction would provide a good opportunity for focusing activities into development perspective as infrastructure has a strong link to economic development and then largely to the economic growth. Post-disaster reconstruction is found to be an excellent prospect to focus activities for development perspectives. In Sri Lanka, the rate of development of infrastructure facilities is not adequate to support the economic growth (Palliyaguru, Amaratunga, & Haigh, 2007). Reconstruction boom must be complemented with policy reforms and state intervention that would transform such a boom into a more sustainable post-disaster economic growth (Dibeh, 2005).

In the economic research paper of African Development Bank compares the challenges of infrastructure rehabilitation and reconstruction in twelve war-affected economies in Africa: Angola, Burundi, Democratic Republic of Congo (formerly Zaire), Djibouti, Eritrea, Ethiopia, Liberia, Mozambique, Rwanda, Sierra Leone, Somalia and Sudan. The survey has been mainly focused on water, transport, energy and telecommunication sector, which showed very low standard of infrastructure provision in all of the twelve countries. The paper concludes that economies of war-affected countries are beyond the financial capacity of the state to invest on the task of infrastructure rehabilitation and reconstruction (Hoeffler, 2000).

Since war-affected countries are beyond the financial capacity of the state to invest on the task of infrastructure rehabilitation and reconstruction, it is essential private investment as an alternative to public investment in the form of Management Contract, Management Contracts, Build Operate Transfer, Build Own Operate and Divestiture (Dibeh, 2005).

The extent of private participation increases in the order of management contracts, Build Operate Transfer (BOT) and Build Own Operate (BOO) projects and is greatest in divestiture (Selling). As long as countries are undergoing guerilla activities or instability in security private investors are likely to consider the countries unsafe for investment on infrastructure projects. With adequate legal and regulatory framework, attracting private investors is more likely. But it further proves that despite high risk level private investors attracted for cellular telephone networks and electricity and water being essential need of population it is more likely to attract private investors (Hoeffler, 2000).

2.4.3 Postwar Reconstruction

The broad meaning of postwar reconstruction is rebuilding public sector services. Postwar reconstruction consist of two types namely reconstruction and stabilization. Reconstruction activities typically address the immediate issues, which involves process of rebuilding degraded, damaged, or destroyed political, socioeconomic, and physical infrastructure of a country or territory to create the foundation for long-term development. All measures immediately take in reconstruction are restorative, remedying immediate problems. Stabilization is the process by which underlying tensions that might lead to resurgence in violence and a breakdown in law and order are managed and reduced, while efforts are made to support preconditions for successful long-term development. Both reconstruction and stabilization activities should be carried out with a longer-term view of how the activities will affect future development of the system of governance and the economy. Public service restoration is carried out in conjunction with the existing public authorities, except in the extreme case of complete collapse of the state. Public service restoration has important implications for the legitimacy of public authorities (Army, 2008); (Brinkerhoff & Johnson, 2009).

The United Nations Programme in Public Administration and Finance has been engaged in public sector improvement and governance reform, rehabilitation and reconstruction since the inception of the United Nations in 1948 (Bertucci, 2003). Stability operations are a part of a longer-term continuum in which the ideal public order is restored, the conditions that may have given rise to conflict or may in the future are reorganized, improved practices and skills are introduced to public authorities responsible for services.

and the foundations are set for long-term, sustainable development of the society. Specific activities in public services restoration should take into account the impact they may have on the desired outcomes in this longer-term spectrum (Brinkerhoff & Johnson, 2009).

The Journal of Strategic Studies argues that US prewar planning caused severe problems in postwar reconstruction strategy. Humanitarian relief plans were high and assistance should have been made available Iraq as soon as military operations began. The main reason for increase of insurgency was wrong assumptions, which caused to delay reconstruction programme, and they thought it was straightforward. Second, they assumed that despite the removal of the ministers and their closest advisors from power Government would continue to function without hindrance. Poor interconnection between military and civilian authorities must be very clearly understood by both decision makers. The Iraq experience also demonstrates that military forces must be prepared to play a greater role in postwar stabilization activities than their planning has traditionally assumed. Civilian authorities also need to improve the interagency planning process and their capacities for implementing reconstruction tasks. It further states that prior to plan a combat operation examining of strategic end state is vital (Benshahel, 2006).

Journal of Department of Economic and Social Affairs United Nation argues that postwar reconstruction has three dimensions

- I. Political dimension - Enough national support must be mobilized for the reform to succeed
- II. Economic dimension - Reconstruction requires funds and it is to be organized through public investment or private investment
- III. Capacity dimension - Enough knowledge and skills must be organized.

Reconstruction is an ongoing process that takes time. It is not always unidirectional and at times things may regress. Reconstruction of any nation should not be based on individuals and they should be future focused attempt. In other words, national programmes and policies should reflect society's needs and not a regime's needs (Musoni, 2003); (Castillo, 2001)

The pace and depth of the reconstruction depends very much on the initial conditions, which are unique to each post-conflict situation (Musoni, 2003); (Castillo, 2001).

Concisely the importance of proper postwar reconstruction may create the difference between a permanent peace and a conflict-oriented environment. This fact is strongly argued by the Human Security Centre drawing on the findings of a new conflict terminations dataset from 1946 to 2005 compiled by the Uppsala Conflict Data Programme and funded by the Human Security Centre and the analysis offers a comprehensive description of how wars end in the modern era. The analysis reveals the dramatic influences that the ending of the Cold War had on the way wars terminate, and that far more wars are now ending in negotiated settlements than in military victories. It shows that the number of negotiated settlements doubled in the 1990s, but that their failure rate increased dramatically as well. Since the end of World War II, the manner in which wars end has changed radically. Between 1816 and 1945 there were extraordinarily few negotiated settlements and the overwhelming majority of wars were fought until one side or the other achieved a military victory. However, over the past 60 years mediated settlements have become far more common, the pursuit of victory much less so. In a summary the analysis focuses on the fact that no conflict after the World War II had been ended, rather they were forcefully terminated with the underlying cause remaining. In other words, no conflict was fully ended after World War II and at any given time, the untreated cause can flame a conflict (Human Security Centre, 2006).

This conclusion enlightens the importance of reconstruction since the proper reconstruction can prevent a future conflict and can eliminate the source of a conflict. Therefore, for a country to be peaceful after a conflict the post reconstruction plays the key role and it should be given the utmost importance (Castillo, 2001).

.2.5 . PROJECT MANAGEMENT

2.5.1 Overview

Project Management Body of Knowledge has defined a project as a temporary Endeavour undertaken to create a unique product service or result, which has a beginning and end. PM is the application of knowledge, skills, tools and techniques to project activity to

meet the project requirement. This can be accomplished through appropriate application and integration of 47 logically grouped PM processes comprising of five process groups of Initiating, planning, monitoring and controlling and closing (PMI, 2013). A project is made up of a group of interrelated work activities constrained by a specific scope, budget, and schedule to deliver capital assets needed to achieve the strategic goals of an Agency (Fleming, 2009). This chapter illustrates PM, CPM and Reconstruction Project Management.

2.5.2 Project Management

It has been recognized over the last 30 years that PM is an efficient tool to handle novel or complex activities. Despite project manager applied Western PM theories: knowledge, skills, tools and techniques of PM, sometimes projects end up in failure. However, it is possible to achieve project success even if management fails. In that sense, it can be stated that project become successful despite it is not completed on time at right quality and at budgeted cost. CPM can be defined as process of controlling the achievement of project success (Munns & Bjeirmi, 1996). According to Avot (1969), there are many factors influence success of PM. It would apparently indicators of completion to budget, satisfying project schedule, achieving quality standard and meeting the project goal (Avot, 1969). Munns and Bjeirmi (1996) further illustrates the factors affecting PM to fail that would include

- I. Inadequate basis for project
- II. Wrong person as project manager
- III. Top management unsupportive
- IV. Inadequate defined task
- V. Lack of PM techniques
- VI. Management techniques misused
- VII. Project closedown not planed
- VIII. Lack of commitment to project

A Project Success Plan is a mechanism to achieve the following positive outcomes for the project (Munns & Bjeirmi, 1996).



- I. Ensure all assumptions about the project, and the meaning of success, are aired and discussed, and any misunderstandings and/or disagreements are resolved early in the project's lifecycle
- II. Ensure project team members get to know how to work with each other so that communications throughout the project are efficient and productive
- III. Assist the project manager in keeping the team focused and engaged, especially on projects of long durations

Project Managers and project entire team must understand how to work together successfully meeting the project success plan by communicating well with each other and continuing the team focused and engaged for the entire duration of the project. Likelihood of a successful project outcome is a critical factor of project planning. It is always imperative to give due consideration for project scope, schedule, design, quality and budget. It is equally important to make certain the emotional aspects of project teamwork, team member expectations, their way of working, their personal aspirations for the project and their assumptions on how the project will unfold. A project success plan is a method to bring out these emotional aspects as well. It can be a good platform to ensure the whole team continually pulls in the same direction to make the project a success (Gareth, 2012).

Projects in competitive business environment have a greater likelihood of success. It is important to evaluate PM tools and techniques for compatibility with the organization's existing systems, processes and training of end users. This will improve the implementation and effectiveness of controls like PM plan templates, various PM software, and management techniques including benchmarking, Earned Value Analysis (EVA), Quality Function Deployment, Project Risk Assessment, Schedule Compression Analysis, and Action Item Report. The accruing benefits include improved tracking and control of project costs, schedule and deliverables, reduced risks and liabilities, ability to meet and potentially exceed quality standards and performance benchmarks, competitive edge and a better-motivated and competent project team (Pinheiro, 2010)

Project conceptual has advanced significantly last decade and instead of seeing a project as a job project manager recognizes project as a way to reach organizational and societal

prosperity. The aim should not be detached from organization strategic and long-term goals. Project definition, planning and success assessment will all become an integrated part of strategic planning and strategic management in organization. The measure of assessment should be set prior to project implementation for strategic goal of organization. These goals should be incorporated during project initiation into the decision making process of top management. The multidimensional framework of project success may help articulate project expectations in an era of increased involvement and integration. Specific project should focus on its explicit dimensions and these dimensions should be determined according to the particular project type (Shebar, Levy, & Dvir, 1997). Kuen et al (2009) identifies success factors evolved over time two decades ago still play significant roles in ensuring project. These three factors are top management support, clear project mission and competency of the project team (Kuen, Zailani, & Fernando, 2009)

Hail et al (2012) focuses five groups of key barriers for project success, which include the nature of construction, traditional contractual arrangement, and construction participant, characteristic of organization and construction management approach. Further coordination is observed as a prerequisite to a success of construction project. (Hai, Yusof, Ismail, & Wei, 2012).

Project forecasting is significantly important for project monitoring and controlling. Forecasting is a critical component of PM. Project managers must be able to make reliable predictions about the final duration and cost of projects starting from project inception. Such predictions need to be revised and compared with the project's objectives to obtain early warnings against potential problems. Therefore, the effectiveness of project controls relies on the capability of project managers to make reliable forecasts in a timely manner (Kuen, Zailani, & Fernando, 2009).

Project Managers to track and control the progress of construction project adopt various methods. Earn Value Method (EVM) is one of the powerful tool commonly used for project forecasting in construction industry. EVA is a well-known PM tool for monitoring and forecasting the project performance such as time and cost.

EMV is recognized as a viable method for evaluating and forecasting project cost performance. However, its application to schedule performance forecasting has been limited due to poor accuracy in predicting project durations. Recently, several EVM-based schedule-forecasting methods were introduced. EVM is a methodology used to measure and communicate the real physical progress of a project and to integrate three critical element of PM; scope, time and cost management (Vanhoucke, 2009).

The basic concept of EVM is more than a unique PM process or technique. The objectives of an EVMS are to:

- I. Relate time phased budgets to specific contract tasks and/or statements of work
- II. Provide the basis to capture work progress assessments against the baseline plan
- III. Relate technical, schedule, and cost performance
- IV. Provide valid, timely, and auditable data/information for proactive management action
- V. Supply managers with a practical level of summarization for effective decision-making
- VI. In modern PM EVM is considered the best form of tools to monitor progress in critical projects (Vanhoucke, 2009)

2.5.3 Construction Project Management

Munns and Bjeirmi (1996) states that it is inappropriate to make the PM team totally responsible unless client takes an increased interest in the development and use of the project (Munns & Bjeirmi, 1996). The success of a project could be accessed through three assessment based not only on PM techniques but also on other external criteria which are important for the successful implementation of projects, from conception through development and use, to the final closedown. Thus, for a project to be successful there must, first, be an improved appreciation of the role of PM within projects, and this role must be placed within the context of a wider project alongside other outside criteria and long-term expectations. Second, the project manager must allow the client to

contribute actively in the planning and production phases and at the same time the project team involvement has to be extended into the utilization phase.

This would be accommodated properly in a project evaluation technique that examines not only the implementation processes but also the economic and financial performance. Finally, one must always bear in mind that successful PM techniques will contribute to the achievement of projects, but PM will not stop a project from failing to succeed. The right project will succeed almost without the success of PM, but successful PM could enhance its success selecting the right project at the outset and screening out potentially unsuccessful projects, will be more important to ensuring total project success (Munns & Bjeirmi, 1996).

Coordination in construction PM plays a crucial function throughout its project life cycle. It has been identified five groups of key barriers constitute of the nature of construction, traditional contractual arrangement, construction participants, characteristic of organization and construction management approach which is depicted in Figure 2.1.

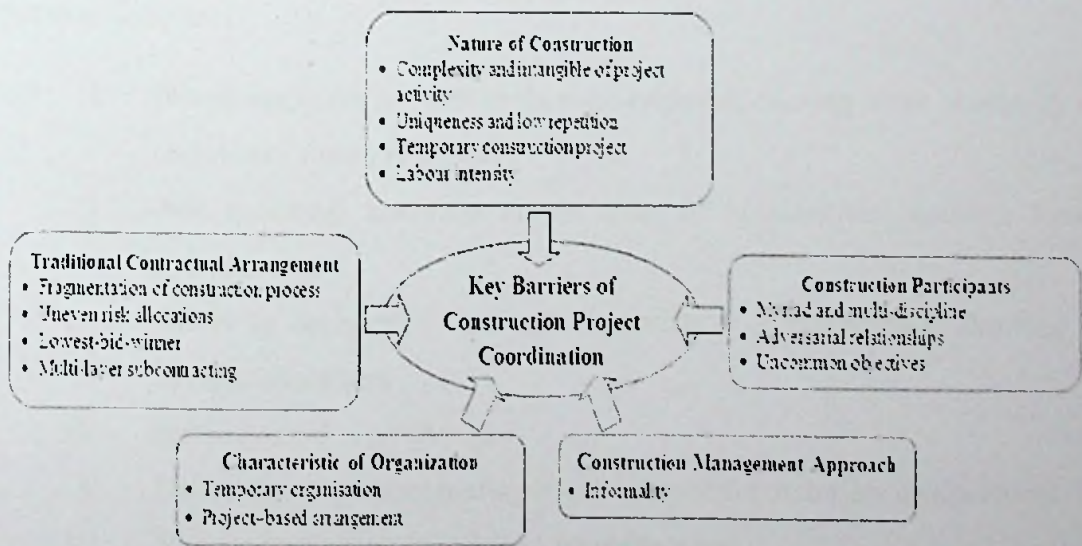


Figure 2.1: Key Barriers in CPM

If the key barriers can be identified at the project implementation stage, it would be easier for project managers to develop a strategy to tackle these barriers for optimal improvement of the overall project performance. On the long run it may encourage the

construction participants to formulate an innovative management and procurement system to utilize at optimum advantage (Hai, Yusof, Ismail, & Wei, 2012).

Apart from the key barrier mentioned above, development in overall project performance can be achieved by developing a strategy for material management. Construction materials usually constitute a major portion of the total cost in a building construction project. Materials management is made problematic by materials shortages, delays in supply, price fluctuations, damage and wastage, and lack of storage space. Kasim, Anumba & Dainty (2005) highlight factors which govern Material Management (Kasim, Anumba, & Dainty, 2005).

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- I. Receiving materials before they are required, causing more inventory cost and deterioration in quality
- II. Not receiving materials at the time of requirement, causing loss of productivity
- III. Errors in decisions to purchase materials with reference to drawing and design documents
- IV. Subsequent design changes
- V. Difficulty of contract management for specific materials procurement
- VI. Vendor evaluation criteria can be inadequate
- VII. Vendor payment management can be complex due to the nature of material
- VIII. Piling up of materials inventory and controlling and management of surplus materials (Kasim, Anumba, & Dainty, 2005)

2.5.4 Reconstruction Project Management

Large-scale disasters such as earthquakes, storms, hurricanes, intense precipitations, droughts, heat waves, cold spells, and thunderstorms and lightning regularly occur over the globe causing huge loss to the society, which create long-lasting consequences on socioeconomic development. From an economic perspective, disaster can be defined as a natural disturbance to the function of economic system creating significant impact on assets, production line, or consumption. However, these losses are divided as direct and indirect losses. Direct losses are the immediate consequences of the natural disaster, which often classified into direct market losses and direct non-market losses. The losses that are traded on the market or rebuild by purchase are direct market losses. Non-market direct losses include all damages that cannot be repaired or replaced through purchases on a market such as health impacts, loss of lives, natural asset damages and ecosystem losses, and damages to historical and cultural assets (Ophiyandri, Amaratunga, & Pathirage, 2010).

After the disaster, reconstruction plays a vital role. Immediate reaction to control and manage the situation is compulsory. The Royal Institution of Chartered Surveyor (RICS) COBRA Conference, which is held annually states importunacy of the need to develop a project risk management approach for community based post disaster reconstruction to ensure the success of the reconstruction projects. Secondly, it focused on the application of risk management principles during the pre-construction phase of the community based post disaster housing reconstruction projects. However, applications of these concepts in practice are less common in post disaster reconstruction. As a result, there is a need to carry out the risk management process during the entire life cycle of the project, from conceptual phase to operation and maintenance phase. It finally concludes following

- I. Risk management process should carry out through the entire life cycle of the reconstruction project that cover planning, initiating, execution, monitoring and close-up stages of the processes
- II. The application of risk management process in community based post disaster reconstruction is aim to ensure the project objectives can be met

- III. Risks in pre-construction stage of community based post disaster reconstruction are more important to be managed compared to the construction stage (Ophiyandri, Amaratunga, & Pathirage, 2010)

A paper by Broadbent, Susan G; Broadbent and Michae D shows that no stakeholder is satisfied with the way of addressed Asian Tsunami, Pakistan Earthquake or Hurricane Katrina. Each stage in the disaster management cycle applied to specific incidents require considerable amount of resources in form of finance or equivalent that will be required to mobilize unskilled labour, semi-skilled labour, skilled labour, management, materials, consumables, plant, equipment, vehicles and machinery. The resources required for the effective management of disasters should never be underestimated. Aircraft, helicopters, and essential operational backup do not come cheap and are sometimes scarce, but they are often essential for a timely response in some locations as well as for specific incidents. International support would also set out to underpin the full spectrum of beneficial social, economic and environmental matters relating to all stakeholders interests, whether these be for disaster victims or the wider global community (Broadbent & Broadbent, 2005).

2.5.5 Postwar Reconstruction Project Management

Reconstruction is a way of winning the heart and mind of people suffered through the agony of war. Managing this project is highly technical and need to exercise past experience, historical data or lesson learned from other countries.

U.S. Army War College strategy research paper states that due to wrong assumptions, improper planning and lack of management policies US spent over twenty billion dollars on post-war reconstruction to keep Iraqi population satisfactory but it did not directed to satisfactory results. Therefore, it has been examined and identified eight critical areas peacekeeper need to focus prior to implement reconstruction program.

Lesson Number One - Assembling the “Right” National Team is Paramount.

Iraqi postwar reconstruction is the most challenging operation US has ever undertaken since World War II. Even in World War II, it takes almost two years to develop Marshal

Plan to ensure successful delivery to European countries. The planning for post conflict infrastructure should take place in conjunction with combat operations and both to be considered equally importance in order for both to be successful. It further states that implementation of postwar reconstruction program moves at very slow space as planning process outsourced to ad-hoc staff and private enterprises without seeking assistance from federal engineering construction agencies within the Army, Navy and Air Force. However, rebuilding Germany and Japan in World War II achieves though strong military leadership and a policy focused on managing technical infrastructure priorities while maintaining a military reconstruction unity of command over a long period. Assembling the right and competent team is of paramount importance to successful rebuilding.

Lesson Number Two - Unity of Effort is Crucial

Multiple agencies execute their own approach independently while United States Agency for International Development (USAID) under the Department of State had its own vision and projects.

Lesson Number Three - National Objectives Must Drive Programme Pace and Scope

The big mistake is to focus on the large-scale reconstruction projects at the expense of meeting the Iraqi's day-to-day needs. The proposed reconstruction programme missed what Iraqi people really needs in the short-term. Further construction gets delayed using tailored design for small project, which could have been done, on a modular standard design. Most of the local infrastructure rebuilt could have been completed faster and would have had a greater impact if early programmers had implemented designs that are more standard.

Lesson Number Four - Security Drives Execution

Insurgents in Iraq targeted the infrastructure by making severe destruction to delegitimize newly elected Government and to drive out the United States led coalition. There were several incidence insurgents threatens contractors to quit projects

Lesson Number Five - The Importance of Decentralized Execution and Authority

The contractors are reluctant to participate in reconstruction programme for fear of being attacked by insurgent group. Therefore, decentralized planning and execution become more effective to divert insurgent group attention that contractors are not associated with supporting the newly elected government.

Lesson Number Six - Outsourcing is No Panacea (solve all problems)

The initial strategy for reconstruction of Iraq is to outsource them as cost plus contract to US multinational firms that are not design to operate in war environment. Those projects end up with half completed structure while spending more than 75% of project cost due to uncontrolled corruptions, fraud etc.

Lesson Number Seven - Maneuver Commanders Must Embrace Reconstruction Operations

Maneuver commanders guessed and identified the real priorities in the field and managed to complete some constructions with Iraqi contractors as fixed-priced contract successfully.

Lesson Number Eight - Retooling a Contracting Bureaucracy for War is Overdue

United State Congress has not reviewed bureaucratic rules to suit for reconstructions to achieve expedient completion of infrastructure and existing rules are suitable for peacetime. Well-developed peaceful democracy is not suited for a war torn country dealing with insurgency (Miles, 2007).

Similar to Iraqi incident reconstructions in Northern and Eastern provinces are being done mainly by Sri Lanka military weakening international humanitarian efforts and worsening tensions with the ethnic Tamil majority. Majority of people live in makeshift arrangements, without proper income, struggling to find a living and facing myriad of hardships. The heavy militarization of the provinces by introducing scattered military deployments around the entire Island to protect against the renewal of violent militancy is in fact deepening anger of northern Tamils and threatening sustainable peace. Major new

military bases require acquisition of large amounts of public and private land continued displacement of tens of thousands of Tamil People (Keerawella, 2013).

Every post-conflict reconciliation process has its unique characteristics thus requiring a unique solution. Sri Lanka is no exception in this regard. Developing infrastructure and building institutions and providing inputs for economic activities alone do not achieve long lasting peace and durable reconciliation. It is equally important to capture the hearts and minds of the people and eradicate the root causes and address those issues resolutely to assure recurrence of such unfortunate conflict will never occur in Sri Lanka (Tennakoon, 2012).

2.6 INFORMATION SYSTEMS FOR CONSTRUCTION MANAGEMENT

2.6.1 Overview

Construction project involves many stake holders during its entire life cycle of the project from inception to project close up. Designated consultants, architects, contractors, or consortium of those, client itself or funding agency depending on the type of contract manages projects. Project managers are necessarily to integrate all the functionalities to make certain that project delivers at right time within the budget to the required quality standard. Despite Information System provides potential benefits by integrating above functionalities to enhance performance of organization convincing higher management to embrace its use and implementation of information systems (IS) has proved a difficult task (Kasim & Ern, 2010).

2.6.2 Information Systems

The data is an raw facts that could exist as number or statement and it does not have a clear meaning. However, these data could be transformed into meaningful number or statement, which is called information. The common definition of information is that these data has been processed so that they are meaningful. Information is generated through the transformation of data. Although information is a beneficial resource for individuals and organizations, all the information cannot be considered useful. Sometimes providing of information too early or too late will not be worthwhile

information. There the validity of information is time dependent. A system can be defined as collection of components that work together towards a common goal. The objective of a system is to receive inputs and transform into meaningful resource. Information system is any combination of information technology and people's activities that support operations, management and decision-making. In a very broad sense, the term information system is frequently used to refer to the interaction between people, processes, data and technology. In this sense, the term is used to refer not only to the Information and Communication Technology (ICT) that an organization uses, but also to the way in which people interact with this technology in support of business processes. (Hardcastlw, 2008).

2.6.3 Evolution of Information Systems

IT in the 21st Century - It is important to identify data and information. Data is raw fact and take a form of number or statement. Then information is generated through transformation of data. System can be defined as a collection of components that work together towards a common goal. The objective of system is to receive inputs and transform these to output. There are five components of a generic system in terms of input, process, output, feedback and control. Role of information system to provide information to management will enable them to make decision to achieve enterprise goal. Information, and generally, the technology providing it, has become a vital strategic and economic asset of companies and organizations today. Its rapid development as regards computing systems and software packages and telecommunication networks, has significantly improved the management of information, and particularly its disposition and diffusion. Consequently, IS, the science of gathering, storage, transmission, and processing of information, gradually has to become a science of communication (Hardcastle E. , 2008).

2.6.4 Benefits of Information Systems

Information system helps to communicate with employees and patrons. Communication is one of the most important work ethics that can be used within the work place. Any business lacking communication would automatically fail. Every company is based

around good communication between employees and patrons. Information system is any combination of information technology and people's activities that support operations, management and decision-making. An information system can be defined as any means of communicating knowledge from one source to another, or from one person to another. IS typically refer to computerized methods of searching, storing and retrieving information. An information system is all about providing the most usable information needed, and is there to empower users and equip them with the tools to do their jobs most effectively and efficiently.

Sufficient research literature available to measure the effect of use of information technology (IT) in construction industry by dividing it in to two domains; Communication Systems and Technical Decision Support Systems where communication domain involves all the common means of communication while later involves all computer applications other than for communication.

European Journal of Scientific Research reveals that effect of using IT in construction industry has a positive impact on performance of the construction firm. Research has analyzed the degree of IT use and factors affected in the performance of construction industry.

Malaysian Construction Industry illustrates following statistics. activities computerized in the firms.

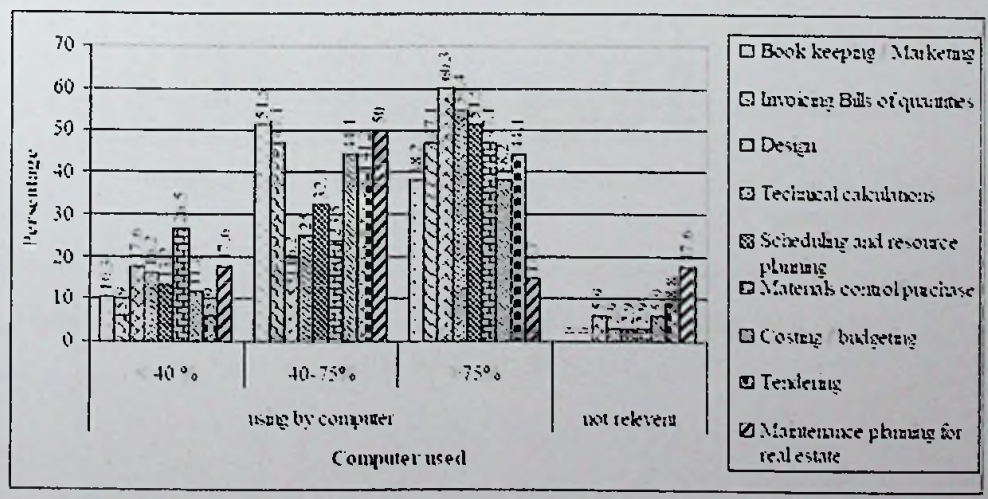


Figure 2.2: Computer Used in the Firms

Source: (Gaith, Khalim, & Ismail, 2009)

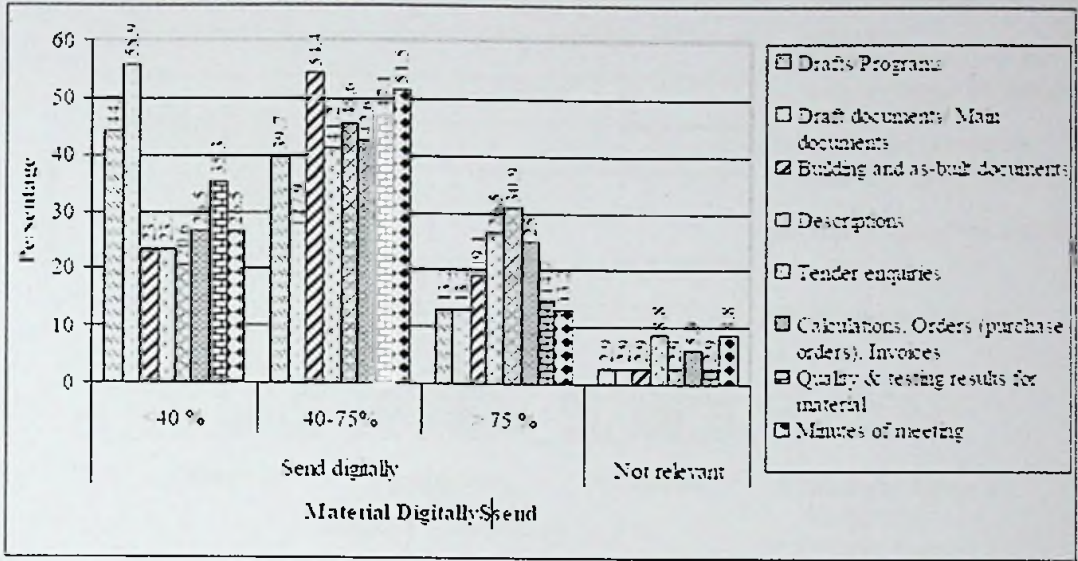


Figure 2.3: Materials Digitally Sent at Firms (Internal and External)

Source: (Gaith, Khalim, & Ismail, 2009)

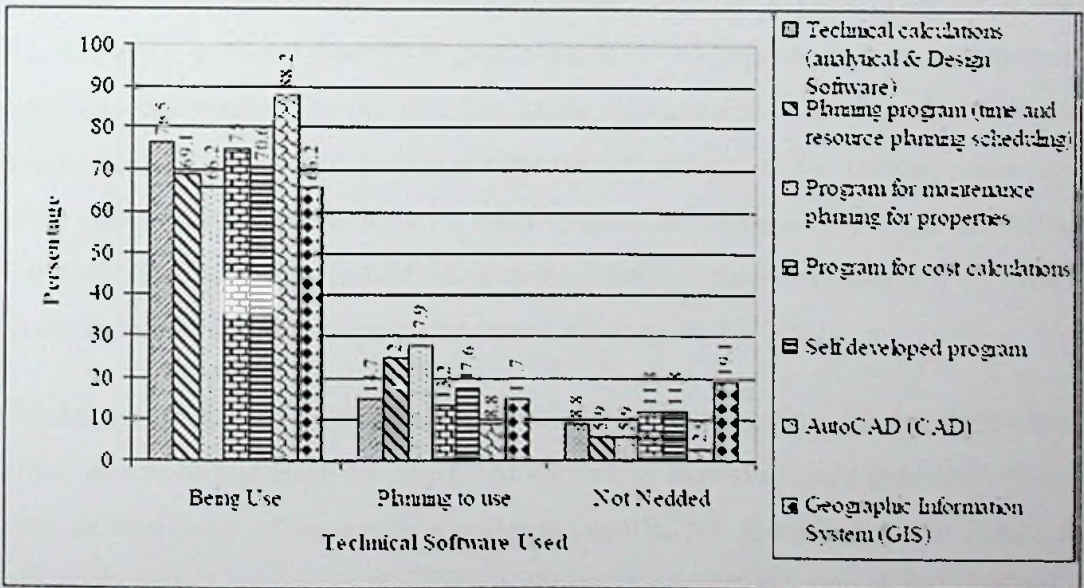


Figure 2.4: General Software in Use and Possible Future Software

Source: (Gaith, Khalim, & Ismail, 2009)

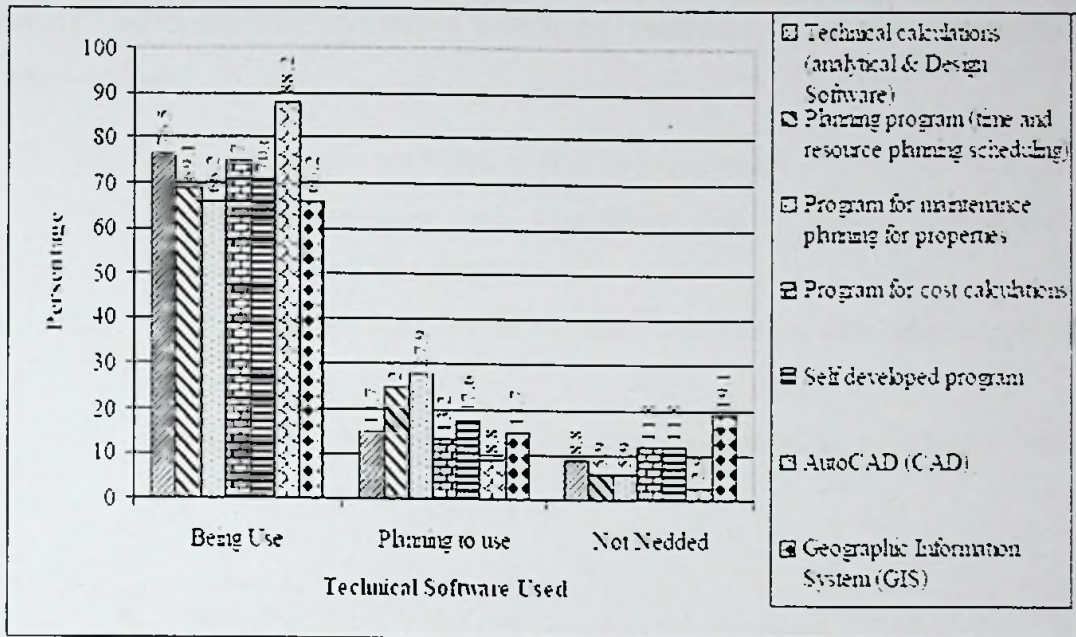


Figure 2.5: Technical Software's Use at the Firms
Source: (Gaith, Khalim, & Ismail, 2009)

Finally, it has concluded that General and Technical Software Use would have to increase greatly if the firm performance is to be substantially improved (Gaith, Khalim, & Ismail, 2009). However, cost incurred for implementation of information system in construction is generally supposed to be the decisive factor. Nonetheless the Australian Journal of Construction Economics and Building concludes that cost of the package was not the decisive factor and compatibility with other systems and ease of use were considered to be the most significant and important features. Performance of packages with respect to the features was much more significant (Scott, Cheong, & Li, 2002).

Construction industry being characterized with high fragmentation, low productivity, cost and time overruns, and conflicts compared with other manufacturing industries is mainly depend on efficiency of supply chain management(SCM). Coordination in construction supply chain is the core issue to improve construction performance. Single information communication point enabling data sharing and improve coordination in supply chain. This enhances communication transferring efficiency and thus by performance efficiency of the firm.

However, following four challenges should be overcome for those wanting to use information hub.

- I. Information asymmetries can lead to exploitation
- II. Sharing information with a supplier that is also a competitor can jeopardize confidentiality
- III. Many managers are not ready to share information with other supply chain members
- IV. Management has not achieved internal integration of IS and business processes in many firms

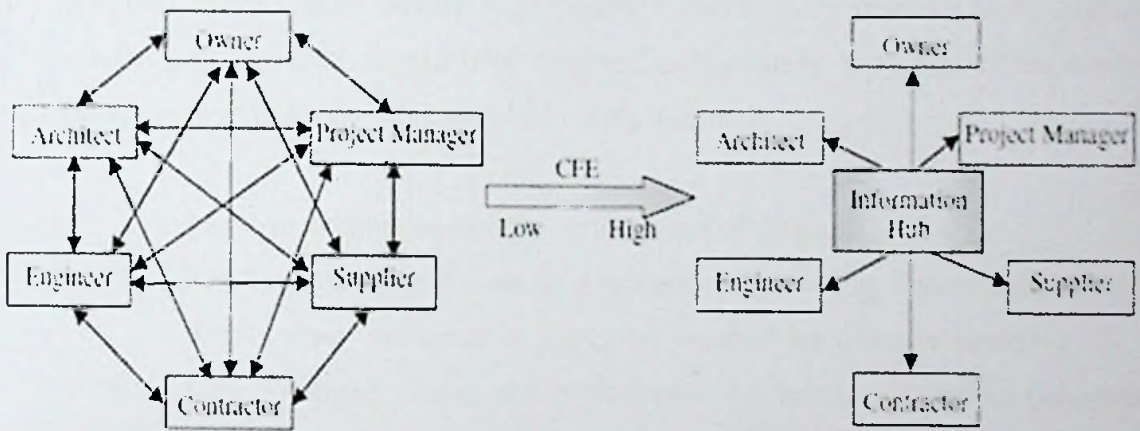


Figure 2.6: Information Hub of Supply Chain

Source: (Xue, Wang, Shen, & Yu, 2007)

Successful CPM requires effective collaboration and coordination between multiple project team organizations. Project managers today may employ web-based communication at all the stages of the construction projects to integrate the efforts of the team members and requirements of the stakeholders. Planning and implementation of adoption of web based communication by an organization should consider business objectives of the organization, intra-organization and inter-organization communication procedures, industry requirements, technical issues like standardization of information, availability of electronic database etc. and associated managerial issues. As the construction industry has been slow in the adoption of ICT technologies, how to develop a strategy to encourage, facilitate, then streamline web-based communication for

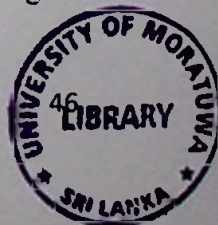
everyday PM routines remains a big challenge. Industry leaders, for example, large corporations and professional bodies, may develop strategy plans for the same at industry level and help SMEs in its adoption. The real shift will occur when there is a regular requirement of web-based communication at project levels and organizations can see the benefits in doing so and the viability of investing in the technology (Ahuja, Yang, & Shankar, 2006).

2.6.5 Construction Project Management Information Systems

CPM Systems which provide solution for tactical and strategically problems in industry mainly comprise of ERP in Construction, PM Server and Construction Industry Information. CPM solutions enable large organizations to keep track of their ongoing construction projects, analyze data and conform to regulatory and legal requirements. This improves organizations capacity in following matrixes.

- I. Improve on-time/on-budget performance of projects
- II. Enhance planning and analysis systems by providing accurate and timely details of key performance indicators required for financial planning
- III. Gain synergies across the organization by bringing together enterprise planning, design, procurement, construction and facilities team onto one collaborative system
- IV. Create and enforce consistent processes and best practices across the organization
- V. Understand and evaluate physical assets such as buildings, manufacturing facilities and transportation

Among the various construction PM solutions available in the globe ERP systems called SAP R/3, SAP BI, LN BaaN and PM management systems such as MS project, Project Libre, Primavera, Pro-Contractor MX take lead role in construction industry. ERP is now being hailed as a foundation for integration of organization - wide IS. ERP systems link together an organization's operations such as accounting, finance, human resources, manufacturing and distribution. However, it does not mean ERP system will give strategic benefit for the company.



Journals of IBIMA expresses organization maturity level, implementation approach, organizational culture, organization's business process, top management commitment and other external issues were the factors which influence the ERP implementation success.

It expressed existence of three levels in the organization based on its hierarchy as illustrated below.

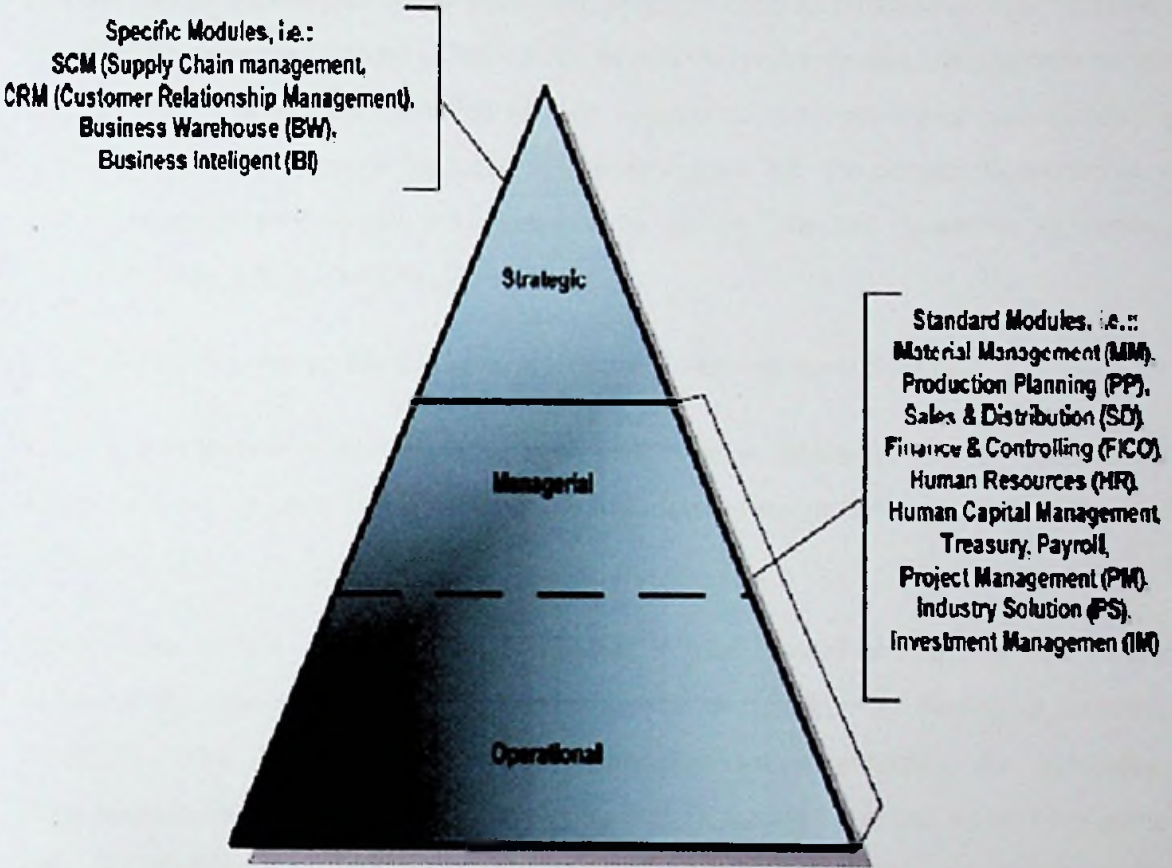


Figure 2.7: Three Levels of an Organization

Source: (Dantes & Hasibuan, 2011).

Implementation of ERP in an organization would give both tangible and intangible benefits developing strategically and tactical impacts. Strategic impact will affect strategic things in the company as well as the company's future business. Tactical impacts will affect the internal affairs of the organization, both on the managerial and operational level. The research concludes that ERP implementation in Indonesia gives more significant tactical impact rather than strategic impact. (Dantes & Hasibuan, 2011).

A construction project involves large number of parties, skills, and specialties, which are independent variables. Better communication flow of information between these functional teams/ parties is good way to bridge the gap between different parties and achieve the overall goals of the project (Zeng, Lu, & Skibniewski, 2012). IT technology enables parties electronically do some functionality such as purchasing orders, paying invoices and processing credit checks. Flow of material order, product, transportation and delivery of goods, strategic process service, support service, personnel and accounting from the business process, bring a better communication into the construction process. A proper, accurate and timely information flow system has the capability to remove weakness (Donyavi & Flanagan, 2009).

2.6.6 Modes of Hosting for Enterprise Resource Management Systems

There is a multitude of delivery models of ERP systems. However, not all vendors will support all the options. The following are some of the major delivery models for ERP software.

On-premise - Most ERP customers still use this traditional model. In this model, customer buys the software, and the vendor gives it to customer (as download, or actual DVD/CD). The customer is typically responsible for maintaining the technology infrastructure. Buyers acquire a block of perpetual licenses and install on an own server and, if necessary, on individual computers/desktops. Therefore, the customer has complete control over the infrastructure and the data (Gross, 2012).

Hosted – The ERP software requires a server to run, which most do, however most of the organizations may find it too burdensome to have own server in-house. In such a case, many vendors or third parties will allow to use their servers, located in secure data centers, to run the system (Zeng, Lu, & Skibniewski, 2012).

Cloud Based Solutions - In 1980 or so client/server were used to operate computers. When a client wanted to access data or programme, user had to connect to the mainframe, gain appropriate access, and then do his business while essentially renting the programme or data from the server. Instead of running programmes and data on an individual desktop computer, every-thing is hosted in the cloud that is accessed via the Internet (Gross,

2012). Cloud computing lets user to access all applications and documents from anywhere in the world, freeing from the confines of the desktop and making it easier for group members in different locations to collaborate. The given definition for cloud computing is "A model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" (Miller, 2008).

2.6.7 Functions of an Enterprise Resource Management System

Starting in the late 1980s and the beginning of the 1990s new software systems known in the industry as ERP systems which have surfaced in the business industry focusing mainly large complex business organizations. These complex, expensive, powerful, proprietary systems are off the- shelf solutions requiring consultants or advisers to tailor and implement them based on the company's requirements. In these instances, they force companies to re-engineer their business processes to accommodate the logic of the software modules to meet organization's needs (Rashid, Hossain, & Patrick, 2002).

ERP systems are software systems for business management in the areas of planning, manufacturing, sales, marketing, distribution, accounting, financial, human resource management, PM, inventory management, service and maintenance and transportation. The architecture of the software facilitates transparent integration of modules, which facilitate flow of information between all functions within the enterprise improving visibility to all functional and managerial level. ERP system allows enterprises to implement a single integrated system by replacing or re-engineering their existing incompatible or ineffective ICT management. ERP systems have been identified as a method for effective planning and controlling of all the resources needed to achieve enterprises' goal (Rashid, Hossain, & Patrick, 2002).

Further, it illustrates the benefits and the way these benefits can be gained by implementation of ERP to an organization.

Table 2.1: Benefit of ERP Implementation

Benefit	How
Reliable information access	Common DBMS, consistent and accurate data improved reports
Avoid data and operations redundancy	Modules access same data from the central database, avoids multiple data input and update operations
Delivery and cycle time reduction	Minimize retrieving and reporting delays
Cost reduction	Time savings, improved control by enterprise-wide analysis of organizational decisions
Easy adaptability	Change in business processes easy to adapt and restructure
Improved scalability	Structure and modular design with "add-ons." Vendor-supported long-term contract as part of the system procurement
Improved maintenance	Extend modules such as CRM and SCM
Global outreach E-Commerce, e-business	Internet commerce and collaborative culture

Source: (Rashid, Hossain, & Patrick, 2002).

Different ERP vendors provide ERP systems with some degree of specialty but the core modules are almost the same for all of them. The core ERP modules found in the successful ERP systems are as follows:

- I. Accounting management
- II. Financial management
- III. Manufacturing management
- IV. Production management
- V. Transportation management
- VI. Sales & distribution management

- VII. Human resources management
- VIII. Supply chain management
- IX. Customer relationship management
- X. E-Business

Almost all the modules mentioned above involves in construction industry providing numerous benefit in a way of tangible and intangible modes (Rashid, Hossain, & Patrick, 2002). New trend in ERP development and use involves vendors making the software available to client companies on the Internet, which is popular as hosted ERP or Web-deployed ERP. When a company chooses to run ERP systems through a Web-based host, the client company need not to acquire the software or installed at the client's company. Instead, it resides on the vendor's host computer, where clients access it through an Internet connection. Therefore, many companies are interested in web based ERP software as an alternative to the traditional on-premise licensing model. Web-based ERP software is reputed to be less expensive, easier and quicker to implement, and easier to maintain (Zeng, Lu, & Skibniewski, 2012).

2.6.8 ERP System for Data Analysis

The PM module, which is especially developed by a Team of Consultants to cater the Sri Lankan construction industry, is perfect match for organizational need to manage construction projects in an optimum visibility. This Web ERP is an open-source web-based ERP (web ERP) system. The latest release is 4.07.2 released in March 2012. It provides a complete web based accounting and business management system that requires only a web-browser and Portable Document Format (PDF) reader to use. It has a wide range of features suitable for many businesses particularly distributed businesses in wholesale, distribution and manufacturing. It is developed as an open-source application and is available as a free download to use. The feature set is continually expanding as new businesses and developers adopt it. Therefore, ERP systems, which possess following facilities, are used to analyze the effect of IS in postwar reconstruction and construction.

Project Management

The PM module offers numerous facilities comprehensively manage a construction project. Below some of the most vital functions are presented.

View Project Budget

Most vital information for the project managers are summarized in the “Project Budget”. In a glance, the project manager will be able to observe the profit/loss of a BOQ item and the system will highlight the BOQ items without a costing.

View BOQ Items with Rate

The BOQ items with rate can be viewed and it provides a convenient way for the users to analyze the BOQ items with rates.

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View BOQ Items' Rate Analysis

It gets even better with the facility to analyze the BOQ items with rates. Each BOQ item is listed with the rate analysis which is vital information in a project.

View Resource Usage

Resource usage of a project is very important. The PM Module provides the facility to view resource usage in a particular project including the most vital information such as “Received Quantity”, “Used Quantity” and “Quantity on Hand”.

General

- I. Entirely web-based
- II. Runs on any web-server that can Hypertext Processor (PHP) - can use an Internet Service Provider (ISP) instead of having/maintaining own server

- III. Minimal use of JavaScript for maximum compatibility with all web-browsers and web enabled devices. Some small amounts used to improve error trapping and user interactivity
- IV. Produces reports to Portable Document Format - PDF for accurate positioning of text
- V. All reports and scripts easily modifiable PHP text
- VI. All processing on the server and no installation required on client machines
- VII. Multi-language - each user can see the interface in their preferred language
- VIII. Multi-theme - each user can see the interface in their preferred graphical theme

Security

- I. Users can be defined with access to only certain options using a role based model
- II. Options applicable to certain roles can be graphically configured and users defined as fulfilling a given role
- III. Incorrect entry of password (more than 3 times) blocks the account until reset by the System Administrator. This prevents password crackers from breaking the security
- IV. Pages can be encrypted using SSL and Web ERP can be configured to only display pages using SSL to ensure that all information passing over the internet is encrypted
- V. Users can be defined to see only certain modules on the main menu - so menu options that they will not have access to be not even displayed on screen
- VI. Hypertext Transfer Protocol (HTTP) security can be configured over the top of the inbuilt security to provide two levels of security - the first to access the web-server at all and the second to actually get into Web ERP

- VII. An audit trail of which users did what is retained and is automatically maintained based on how long the information is required to be kept

Order Entry

- I. Quotations can be entered and printed as quotations then changed to an order if the customer accepts without re-entering
- II. Customer orders can be entered, maintained, and referenced back to the customer's order number
- III. The cumulative quantity on order for a stock item shows as a demand in stock status inquiries
- IV. The cumulative quantity on order for assembly items shows the demand against its components in the stock status inquiries
- V. The quantity of the order left to invoice is maintained and updated for invoices and credit notes raised against the order
- VI. The orders entered can be invoiced directly with little or no additional input
- VII. Multiple dispatches are possible from a single order. Order retains references to each dispatch
- VIII. Differences from the order are logged when dispatches are not the same as the ordered quantities for reporting delivery in full on time
- IX. Pricing automatically returned based on the customer sales type, branch and currency
- X. Pricing can be set to be effective from specific dates and to finish on a final date
- XI. Pricing is by currency
- XII. Any number of price lists can be maintained. Customers are defined to get their pricing from a specific price list. However, special prices can be defined as an exception for a given customer or even a particular branch of a customer
- XIII. Quantity break discounts across a range of products are automatically calculated based on a discount matrix
- XIV. Packing slips printable on laser or pre-printed stationery

- XV. Automatic freight calculations based on shipping method and delivery address. Orders calculate weight and cubic based on item unit weight and cubic
- XVI. Free form entry of delivery addresses – defaulting to the customer branch physical address
- XVII. Automatically recurring orders can be entered and if the orders are for "service items", the order can also be automatically invoiced
- XVIII. Daily sales reports and ad-hoc sales graphs
- XIX. Delivery In Full On Time reporting

Taxes

- I. Very flexible taxation options suitable for Canada, US, South Africa, UK, Australia, NZ and most other countries
- II. Tax rates dependent on the type of product - using tax categories
- III. Tax rates dependent on the location of the warehouse dispatched from
- IV. Tax rates dependent on the location of the customer
- V. Multiple taxes payable to different tax authorities
- VI. Each tax posted to different user-definable general ledger accounts - if linked to AR/AP

Accounts Receivable

- I. Full on-screen inquiry on a customer's account, complete with invoice details and narrative which appeared on the invoice. Drill down to source document – invoice or credit note
- II. Invoice can be emailed to customers together with PDF attachments dependent on items invoices eg. warranty, datasheets, instructions, manuals etc.
- III. Inquiries on payments received will show how a payment was allocated to invoices and the difference on exchange attributable to each invoice
- IV. Full integration with stock records and general ledger - a full trail of journals for each transaction is maintained – a drill down to the general

ledger transactions for each transaction on a customer's account is available from the customer inquiry page

- V. Flexible general ledger postings for sales and if required as well cost of sales based on sales area and product category. General ledger integration is optional
- VI. Open item - full analysis of the outstanding balance is maintained and printed on statements for maximum information to the customer
- VII. Statements can show transactions settled this month or only outstanding transactions as at the date of printing
- VIII. Flexible user definable sales analysis reports to PDF or spreadsheet (csv – comma separated values). Report definitions can be saved for re-running or automating email delivery from a scheduled job
- IX. Any number of branch – delivery addresses can be added serviced by different sales people with different tax authorities and different areas for sales analysis purposes
- X. Unlimited accounts and unlimited number of branches (ship to addresses) for each account are available
- XI. Shipping method updated by branch
- XII. Customer accounts can be in any currency. Individual rate for each invoice, default to currency table rate
- XIII. Currency table can be set to be automatically updated daily from European central bank published rates
- XIV. Invoices and credit notes created in PDF
- XV. Email of invoices and credit notes
- XVI. Credit notes can be produced from one click taking the details of a selected invoice for subsequent modification
- XVII. Transaction inquiries show sequence of invoices, credit notes and receipts entered.
- XVIII. Option to produce integrated Google maps of customer locations (and suppliers)

Inventory

- I. Unlimited number of warehouses (stocking locations), stock quantities are maintained for an unlimited number of locations
- II. Selling prices for a stock item can be set for each sales type defined in any currency allowing great pricing flexibility. Pricing can also be set specific to an individual customer account or even a specific customer branch
- III. Automatic back ordering, Sales orders yet to be delivered can be automatically back ordered at the time of invoicing or the balance of the order canceled as appropriate
- IV. A history of stock movements is maintained by stock item allowing full traceability including serialized and lot/batch numbered stock items
- V. Allows Dummy (service) stock items, which can be invoiced, priced, cost but with no stock record maintained for items such as labour or services
- VI. Kit-set parts can be defined. An order for a kit-set part explodes into the components defined for the parts at the predefined quantities as extended by the number of the kitset item ordered all priced individually. These component quantities are then available on the order for modification by the use
- VII. Assembly parts can be defined in a similar way to kitset. These parts exist only for ordering, pricing, invoicing and sales analysis. No stock balance is maintained, instead the quantities of the components are updated in proportion to the quantity defined in the assembly
- VIII. Invoice and credit note inquiries are linked to stock movements so the detail of items sold on an invoice can be queried calling up the actual invoice or credit note that caused the stock movement
- IX. Standard cost manually maintained or automatically maintained weighted average cost
- X. Inventory usage by month inquiry by location and over all locations
- XI. Inventory planning report showing the last 4 months and the current months sales including sales of assembly components

- XII. Receiving inventory against purchase orders creates journals in the general ledger to reflect the increase in stock value and the amount owing to a supplier
- XIII. Stock transfers to other inventory locations can raise transfer dockets.
- XIV. Re-order quantities can be maintained
- XV. Inventory adjustments can create general ledger entries to reflect write on or off stock value
- XVI. Inventory cost changes can create general ledger entries to reflect write on or off stock value
- XVII. A stock taking system allows business to continue recording system stock quantities at the time of counting adjustments created based on these quantities and the sum of all quantities entered as counted for the item. General ledger integration creates the necessary journals to reflect the changes to stock values
- XVIII. Controlled items allow referencing of each stock movement to the bundles/batch references
- XIX. Unlimited user defined fields specific to each inventory category for additional important information required to be stored against items
- XX. Weighted Average (automatic) or standard (manually maintained) costing

Purchasing

- I. Purchase orders and suppliers can be in any currency
- II. Supplier item descriptions and pricing (in the currency of the supplier) for purchased items can be maintained. Purchase orders automatically use these prices. The same item can be purchased from many different suppliers
- III. Quantities on order show on inventory status inquiries by inventory location to receive into. Quantities on order also show on planning reports
- IV. Goods received can be entered up to the purchase order quantity plus a user definable percentage allowance for over delivery

- V. Goods received are sequenced as a Good Receive note (GRN) and a record is retained for every stock movement referenced to the GRN
- VI. Purchase orders record the quantity received and the quantity invoiced as well as the original quantity ordered
- VII. Purchase orders can be emailed to one of the defined supplier contacts email addresses
- VIII. Inventory planning report can be produced based on a 3 or 4 month lead time showing suggested quantities to purchase based on the maximum of the prior 5 months usage
- IX. Purchase orders can be entered for nominal items i.e. non-stock items with a general ledger code to be entered to specify how the general ledger integration postings should be made
- X. Purchase order approval levels and authorities can be defined. With all approvals required by an authorizer easily accessible for authorization
- XI. Shipment costing can be set up across several purchase orders from the same supplier choosing only those lines that have been dispatched together
- XII. Supplier units and purchasing prices can be maintained with a preferred supplier for each item. Orders can be entered referring to the supplier's item code and description and in the suppliers unit, converting to the business units for all internal purposes

Accounts Payable

- I. Suppliers can be defined in any currency
- II. Invoices can be entered as a cost of a shipment for apportionment between the items on the shipment
- III. Invoices can be entered against goods received with a user definable allowance for over invoicing. Thus ensuring payment is only made for goods received
- IV. An aged listing of balances is available as a PDF showing either summary balances or the detail invoice by invoice of the balance of the account

- V. Retrospective allocation or de-allocation of payments to invoices. With differences on exchange reported
- VI. Supplier invoices cannot be entered with the same reference as prior invoices
- VII. Supplier invoices/credits can be entered against the internal record of goods received from the supplier. Providing an internal check to ensure only those goods received are paid for
- VIII. Supplier invoices for freight/duty etc. can be charged against shipments from other suppliers
- IX. Supplier invoices can be entered directly against multiple general ledger coding
- X. Inquiry on Suppliers account shows all transactions
- XI. Fully integrated general ledger postings – keeps the creditors control account in line with the supplier balances in local currency
- XII. Payment run creates payment transactions based on payment of all due invoices not flagged as held
- XIII. A petty cash expense reimbursement module is available for sales people to enter their claims

Bank

- I. As many bank accounts as required can be set up details and account number can be held against the bank account definition
- II. Bank accounts can be any currency and payments/receipts can be paid in any currency from any bank account
- III. Transfers between accounts are automatically detected by entry of payment to another bank account or receipt
- IV. Online reconciliation statement based on matched and all entered transactions
- V. Calculation and posting to GL of unrealized exchange differences in foreign currency bank account balances

General Ledger

- I. Automatically maintained periods, reporting over any range of periods with no rollover procedure at period end
- II. Balance Sheet and Profit and Loss Statements
- III. Reporting against budget
- IV. Inquiry on any account over any period
- V. Posting journals into any number of periods ahead or periods before
- VI. Reversing journals
- VII. Accounts can be grouped using relational methods ie flagged as a member of user definable account groups - rather than the old chart of accounts numbering structure.
- VIII. Account groups can be nested so hierarchical structures can be accommodated - detailed profit and loss, balance sheet and trial balance all use account group structures to display reports
- IX. Posting to prior periods can be disabled based on transaction date to prevent prior periods being changed

Manufacturing (Construction)

- I. Multi-level bill of materials - with error trapping to prevent recursive BOMs
- II. Phantom bills - automatically explode into components when a parent work order is created
- III. Automatic cost rolls ups on change of BOM or component costs.
- IV. Works orders can have multiple output items for handling by-products
- V. Optional automatic back flushing or auto-issue of components
- VI. Issues to works orders and receipts of finished goods from work orders integrated to inventory and GL
- VII. Issue of labour and time or other services to works order
- VIII. Work order costing - automatic weighted average cost updates (or manual standard costing updates)

- IX. Usage variances reported to GL - inventory category record determines GL accounts
- X. Demand for components of work orders shows in stock status inquiries
- XI. Full MRP - material requirements planning with master production schedule/forecast maintenance and creation facilities

Contract Costing

- I. Job costing can be created for a selected customer using stock and other requirements. These can be converted into a quotation and if the quotation is accepted a sales order/work order
- II. Issuing stock to the job is handled like any other work order until the contract/job is invoiced
- III. Full report on contract/job variances from quoted costs

Fixed Assets

- I. Asset additions through purchase orders or supplier invoice entry directly
- II. Disposals of fixed assets through normal sales order entry - asset to be disposed can be selected for sale
- III. Fixed Asset register covers a period showing additions, depreciation and disposals for that period
- IV. Integrated GL entries created based on asset category GL codes if creditors and debtors are linked to GL (Sapere (Pvt) Ltd, 2013).

2.6.9 Benefits of Enterprise Resource Planning Systems

The business environment is becoming increasingly complex with functional units requiring more and more inter-functional data flow for decision-making, management of inventory, accounting, human resources and distribution of goods and services. In this context, organizations need to implement modern PM systems to improve competitiveness by cost reduction and better logistics (Shang & Seddon, 2012). As a result, software systems known in the industry now as ERP systems have surfaced in the market targeting mainly large complex business organizations during 1980s to 1990s.

These software solutions, unlike the old, traditional in-house-designed company specific systems, are integrated multi-module commercial packages suitable for tailoring and adding “add-ons” as and when required. Below outlines the list of benefits in rank order from the most frequently heard to the least frequently heard. As an example, 91% of companies accept that ERP deployment enhances enterprise’s technology and productivity.

Table 2.2: Productivity Improvement by ERP Deployment

Rank	Benefits	Percentage
01	Enhanced Technology	91%
02	Efficiency	91%
03	Integrated Information	66%
04	Reporting	66%
05	User friendly	66%
06	Access to Data	50%
07	Customer Service	50%
08	Functionality	41%
09	Communication	25%
10	Security	25%

Source: (Roman, 2009)

Kasim and Ern 2010 conclude that ICT transformation is vital especially in the area of cost effectiveness and in materials handling. Nevertheless, high cost involvement of implementation of ICT in the area of material management has been identified as the main reason for resistance for implementation regardless of maintenance of overall implementation. In addition, the exceptional high cost of specialist software is also a barrier to the upgrading of ICT implementation (Kasim & Ern, 2010)

Murray & Thorpe (1996, cited in Bowden, 2005) argues that many of the problems associated with construction PM in terms of paper-based documentation, duplication, feedback, quality, exchange, awareness, illegibility, format, volume, cost, queries and out of date information could be eliminated by use of IT (Bowden, 2005).

An article submitted to the by a group of Sri Lankan researchers has clearly mentioned the problems of proper Asset Management faced by the defence entities of Sri Lanka. Further, the article proves that deploying ERP concepts can optimize Asset Management and Utilization (Perera, Nanayakkara, & Perera, 2014).

Journal published by Department of IS, The University of Melbourne, Australia, has identified that IS offer following benefits to enterprises.

- I Operational benefits - Cost reduction in terms of labour, inventory, and administration, cycle time reduction, quality improvement, productivity improvement, and customer service improvement.
- II Managerial benefits - Better resource management, improved decision making and planning, performance improvement in a variety of ways in all levels of the organizations (Shang & Seddon, 2012).

One of the ERP benefits is operational improvement. As a collection of highly integrated subsystems, ERP systems can be described as 'tightly coupled'. To be sure, tight coupling facilitates coordination among subsystems and solves the fragmentation of information. As a result, it streamlines a company's data flow and provides management with direct access to a wealth of real-time operating information. For many companies, these benefits have translated into dramatic gains in productivity and speed of business operations (Sari, Hidayanto, & Handayani, 2012).

So many ERP benefits have been claimed by research studies. Nevertheless, from all the benefits stated, not all the benefits can be gained by the organizations. Even a successfully adopted and implemented ERP system does not automatically guarantee full benefits. It is important that ERP is operated as planned and thus provides the real-time information with a desired level of process integration. Any ERP system pushes a company toward full process integration and solves the fragmentation of information (Sari, Hidayanto, & Handayani, 2012).

The managerial and operational benefits are in two ways. Journal of Human Resource Management reveals some of the intangible benefits of ERP implementation perceived by an organization.

- I. Implementation of ERP system transformed operational processes in the company from manual systems and stand-alone operation to integrated operations. Main benefit are cost reduction in terms of operational dimension.
- II. Integrated systems and functions help perform better resource management, more accurate decision-making and better performance monitoring giving benefits from managerial dimension.
- III. ERP system supports company's future growth giving benefits from strategically dimension (Sari, Hidayanto, & Handayani, 2012).

Sufficient literature is available to evaluate the tangible and intangible benefits of ERP when an organization embraces ERP technology with an intention of improving the productivity, efficiency and effectiveness.

However, it is evident that researchers have focused toward benefits at deferent levels depending on the researchers' interest of study. Some researchers have focused into one specific area and have critically studied the respective benefits in that particular area. Having summarized the outcome of benefits derived during literature review process that are focused on different levels / disciplines, benefit achieved by implementing ERP can be framed as indicated below.

Table 2.3: Benefit of ERP Implementation

Benefit	Type	Benefit / Saving (%)
Inventory Reduction	Tangible	32-16
Personnel Reduction		27-12
Reduction of cost of annually inputting information twice		50
IT Cost Reduction		8-14
Order Management Improvement		36-20
Transportation Logistics Cost Reduction		4-9
Cost Reduction		8-14
Revenue / profit Increases		8-23
Procurement Cost reduction		12

Shorten the procurement cycle	Intangible	80
Productivity Improvement		26-20
Financial Close Cycle Reduction		19-44
Cash Management Improvement		4-11
Maintenance Reduction		4-7
On time Delivery		4-6
Monitoring efficiency		23-28
Information Sharing efficiency		53-40
Better Management Decisions		34-56
Strategic Competitive Advantage		45-55

Source: (O'Leary, 2004), (Tatari, 2009), (Wieder, Booth, Matolcsy, & Ossimitz, 2006). (Kasim & Ern, 2010)

There are enough research papers to prove that basic operational benefits of ERP systems are cost and cycle time reduction. There are numerous studies stating that investment in IS to automate transactions can speed up processes, substitute labor, and increase operation volume (Zeng, Lu, & Skibniewski, 2012).

Most Enterprises realize both tangible and intangible benefits after implementation of ERP system. O'Leary (2004) compares tangible and intangible benefits realized by companies with Deloitte consultant (1998) results and outcome is tabulated below (O'Leary, 2004).

Table 2.4: Tangible and Intangible Benefits of ERP

Process	Deloitte %	Current %
Inventory Reduction	32%	16%
Personnel Reduction	27%	12%
Productivity Improvements	26%	20%
Order Management Improvements	20%	36%
Financial Close Cycle Reduction	19%	44%
IT Cost Reduction	14%	8%

Procurement Cost Reduction	12%	12%
Cash Management Improvement	11%	4%
Revenue/Profit Increases	11%	8%
Transportation/Logistics Cost Reductions	9%	4%
Maintenance Reductions	7%	4%
On-Time Delivery	6%	4%

Source: (O'Leary, 2004)

It concludes that Deloitte consulting study and the results of his research support the findings of previous empirical researchers.

Shang and Sedden (2002) further emphasises that companies acquire following five dimensional benefits by implementing ERP.

- I IT accounting benefits: ERP gathers data more quickly and easier, ERP produces results more quickly and easier
- II Operational accounting benefits (time): reduction of time for closure of monthly, quarterly and annual accounts and reduction of time for issuing financial statements
- III Organizational accounting benefits: increased flexibility in information generation and integration of accounting applications, improved decision making, improved internal audit and improved quality of reports – statements of account
- IV Managerial accounting benefits: improved working capital control, increased use of financial ratio analysis and reduction of time for issuing payroll
- V Operational accounting benefits (cost): reduction of personnel of the accounting department (Shang & Seddon, 2012)

Mirbagheri and Khajavi (2013) tabulate ERP Implementation benefits by Degree of Importance against the mean value calculated using Likert scale, which named after its inventor, psychologist Rensis Likert as follows(Mirbagheri & Khajavi, 2013).

Table 2.5: ERP Implementation Benefits by Degree of Importance

Priority Order	Top Benefits	Mean
01	Better resource management	4.39
02	Improved decision making and planning	4.21
03	Support for business growth	4.19
04	Building business flexibility for current and future changes	4.17
05	Customer service improvement	4.09
06	Building cost leadership	4.05
07	Facilitating organizational learning	4.01
08	Cycle time reduction	3.96
09	Generating product differentiation	3.89
10	Quality improvement	3.83
11	Increased IT infrastructure capability	3.81

Tatari (2009) brings empirical evidence to confirm that Construction Enterprise Information System impacts performance by integration and automation of enterprise functions. Following table illustrate benefits of integration and automation of enterprise functionalities (Tatari, 2009).

Table 2.6: Ranking by Mean Values of the Responses on CEIS Benefits

Benefit	Measure	Category Rank	Overall Rank
Operational	Cycle time reduction	1	2
	Productivity improvement	2	4
	Quality improvement	3	8
	Cost reduction	4	12
Managerial	Improved efficiency	1	1
	Improved decision making and planning	2	3
	Better resource management	3	5
Strategic	Support for business growth	1	9
	Generating or sustaining competitiveness	2	11
	Building business innovations	3	16

	Enable expansion to new markets	4	17
	Build better external linkage with suppliers, distributors and related business	5	18
IT Infrastructure	Increased business flexibility	1	13
	Increased IT infrastructure capability flexibility, adaptability, etc.	2	15
	IT costs reduction	3	19
Organizational	Building common vision for the firm	1	6
	Facilitate business learning and broaden employee skills	2	7
	Support business organizational changes in structure & processes	3	10
	Empowerment of employees	4	14

Source; (Tatari, 2009).

After summarizing above outcome based on weighted average, Managerial benefits rank the highest followed by Operational, Organizational, Strategic and IT Infrastructure respectively.

Table 2.7: Ranking by Mean Values of the Responses on CEIS Benefits

Benefit	Mean
Managerial	3.36
Operational	3.59
Organizational	3.56
Strategic	3.39
IT Infrastructure	3.29

Source; (Tatari, 2009).

2.7 SRI LANKAN POSTWAR RECONSTRUCTION AND CONSTRUCTION PROJECTS UNDERTAKEN BY THE MILITARY AND THEIR ISSUES

2.7.1 Overview

In this thesis, It is analyzed the roles and missions performed by the Sri Lankan armed forces in the post-conflict process between 2009 and 2011. Sri Lanka has suffered a violent conflict between the GoSL and the Liberation Tigers of Tamil Elam (LTTE) for nearly three decades. During the three decade of civil conflict, over 80,000 have been killed, 11,656 Tamil Tigers have either arrested or surrendered, and 294,000 people have been internally displaced. Further almost all the infrastructure in the LTTE dominated areas have been completely destroyed or damaged. Having identified the obligation of the Sri Lanka Government to provide humanitarian relief; essential services, rehabilitation, and development support to people in LTTE-controlled areas and begins post-conflict reconstruction (Herath, 2012).

Sri Lanka post-conflict reconstruction falls in to two categories; first to address immediate humanitarian and human rights issues and to establish long-term and sustainable social and economic development in affected areas. Second is to explore for a political solution to address the long-term grievances of minority Tamils.

During 2012 defence seminar in Colombo, Secretary Defence and Urban Development Mr. Gotabaya Rajapaksa, delivering the keynote address, says that demining and resettlement of internally displaced personal establishment of vocational training institute for capacity building are the key priorities. 'Peace Villages' are being created to enable many beneficiaries to continue their rehabilitation without any disruption to their family life and also a special programme are drawn up to facilitate education for them (Herath, 2012).

Applicability of ERP technologies for optimized operations in Military entities is argued in an article where the group of researchers has clearly emphasized the proper approaches for ERP deployments. With a proper deployment of ERP systems and selection of the best technology can lead to optimized management of Defence entities. Further it can argue that with the usage of ERP systems, the PM of special projects under taken by the

military can be optimized and can be monitored smoothly. Further research conducted to discover the factors influencing ERP selection in medium sized construction organizations have resulted in better feasibility in developing countries for proper PM (Nanayakkara, Perera, & Perera, 2014).

2.7.2 Physical Infrastructure Reconstruction and Construction Undertaken by Military

Government of Sri Lanka (GoSL) made possible military to defeat LTTE organization in 2009. It can be argued that terrorism cannot be defeated at all. Some content that identify root causes and trigger causes is a positive approach for successfully dealing with terrorism. Others challenge that consideration of factors of decline is also equally important. Artical under Concepts of Terrorism defines following model showing interconnection of the terms “roots causes”, “trigger causes”, “terrorist activity”, “government activity” and “decline” (COT Institute for Safety, Security and Crisis Management, 2008).

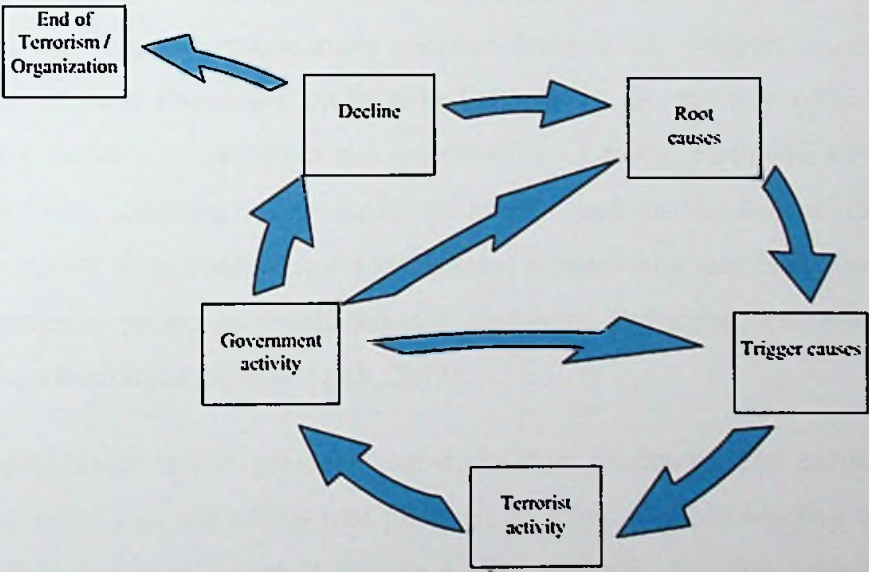


Figure 2.8: Interconnection of the Terms

Source; (COT Institute for Safety, Security and Crisis Management, 2008)

Eradicating one link of above model will not pave path for the end of terrorism as long as other links prevail. In Sri Lanka, the link of terrorist activity of the model has been removed. Nevertheless, the root causes and trigger causes should be well addressed for

sustainable peace. GoSL already initiated reconstruction of infrastructure in war-torn areas as well as western and southern provinces with the assistance of military (Crisis Group Asia Organization, 2012).

Cowen and Coyne (2005) argues that widespread coordination is a vital factor for successful reconstruction. Focusing on achieving any one specific activity or outcome will not bring successful reconstruction towards sustainable peace. Reconstruction of infrastructure is equally important for economic development. However, achieving these outcomes does not guarantee that a liberal economic and political order will be self-sustaining over a longer run (Cowen & Coyne, 2005).

After liberation of Eastern Province from LTTE in 2007, military commenced reconstruction under Eastern Revival. Reconstruction process slowed down when military heavily engaged in crushing LTTE organization in 2009. However, military involvement in Post-War reconstruction has not been restricted to the Northern Province. The military has undertaken many national-development projects in other parts of the country as well. Prominent projects undertaken by the military outside the Northern Province include development and construction of roads, earthworks for infrastructure development, cleaning of internal waterways and establishment of Inland water transportation, construction and management of stadiums and construction of bridges, environmental programs, beautification in Colombo, and repair and renovation of roads and tanks in national parks (Herath, 2012).

Sri Lanka news article provides that renovation of houses and construction of new housing units was one of the first priorities in terms of reconstruction under "Northern Spring" programme launched by the GoSL in 2009. The Sri Lanka military takes responsibility to renovate more than 6,000 houses and construct nearly 7,000 new housing units in this region. It further stresses military has given immense assistance in terms of expertise, manpower and construction plant and equipment for construction of essential infrastructure such as access roads, minor tanks, public buildings, hospitals. Schools have been upgraded quickly to facilitate speedy resettlement. Military has involved in various forms of development related works at different capacity playing a

pivotal role in expediting vital infrastructure constructions throughout Sri Lanka (Rajapaksha, 2012).

Therefore, responsibility of reconstruction and construction of some public and private infrastructure of different Engineering discipline, which support to country's economic development, has already been entrusted to military (Herath, 2012).

2.7.3 Major Issues in Physical Infrastructure Reconstruction and Construction Undertaken by Military

Postwar reconstruction has been happening in the globe mainly fewer than two scenarios: the first is after signing an agreement between two or more actors involved in the conflict and the second is defeating one organization by an opponent. However, in Sri Lanka there were no peace accords to end hostilities and provide a framework for reconstruction as the Sri Lankan military crushed the LTTE. The sole winner of the conflict was GoSL, and government had the ability to implement winner's choice in Sri Lanka. Thus Sri Lankan postwar reconstruction falls into two main categories. The first is immediate addressing of humanitarian and human-right issues. Second is planning for long term and sustainable economic development in the affected areas specially Northern and Eastern provinces.

Followings are the major problems faced by GoSL soon after the defeat of terrorism.

- I. accommodating more than 294,000 IDPs in welfare centers, relief villages
- II. Providing basic needs and shelter; identifying the LTTE cadres who have merged with the civilians
- III. Restoring IDP's economic income to secure their livelihood upon their return home
- IV. Rebuilding irrigation systems for agriculture, damage to railway and trunk-road
- V. Electricity supply line from the national grid
- VI. Rebuilding telecommunication facilities; restoring trade; removing large quantities of mines
- VII. Improving lands that has not been cultivated for years

- VIII. Rehabilitating and reintegrating surrendered or captured LTTE cadres
- IX. Developing economies of liberated areas and the country as a whole (Herath, 2012).

Despite reconstruction and construction of some public and private infrastructure of different engineering discipline have been carried out since 2009, military struggled to deliver the project at right time, to required quality standard within the allocated budget. Following major issues have been highlighted in annual administration report submitted to Ministry of Defence by Tri-Services in the year 2011.

Barrier for Resource Sharing; Idling of resources while some projects run with deficiency of same resource

Cost Management; Cost overrun due to scarcity of resources, redundancy of resources, unforeseen conditions and so on

Human Resource Management; Separation of project teams by geographical boundaries results deficiency of information communication system. *Quality Problems*; Insufficient skilled labour force, time constraints

Procurement Delays; Weak supply chain management

Communication Gap; Communication gap between head office and remote sites, inability to monitor progress in time

2.8 Summary

The literature review, summarizes on postwar Scenarios, IT for PM, Reconstruction Projects with Military involvement and key barriers for project success and construction management approaches. With this clear theoretical background, a methodology should be developed to analyze productivity improvement and information availability in postwar construction that can be achieved with IS.

During the literature review, it was clearly identified that it is essential to have proper management tools and technics for Construction Projects undertaken by the Military.

The wide understanding is provided in the literature review on Military Engineering and Construction, Postwar scenarios and role of the Military focusing on IT for CPM.

Literature review on PM shows the key barriers for project success, which include the nature of construction, traditional contractual arrangement, and construction participant, characteristic of organization and construction management approach. Further coordination is observed as a prerequisite to a success of construction project. It further shows that if the key barriers can be identified at the project implementation stage, it would be easier for project managers to develop a strategy to tackle these barriers for optimal improvement of the overall project performance.

Successful CPM requires effective collaboration and coordination between multiple project team organizations. With project team organizations often geographically separated, project managers today may employ web-based communication at all the stages of the construction projects to integrate the efforts of the team members and requirements of the stakeholders.

Implementation of ERP in an organization would give both tangible and intangible benefits developing strategically and tactical impacts. Strategically impacts will affect strategic things in the company as well as the company's future business. Tactical impacts will affect the internal affairs of the organization, both on the managerial and operational level. , it recognizes the value that IT infrastructure and organizational benefits can contribute to an organization.

Literature shows that many of the problems associated with CPM in terms of paper-based documentation: duplication, feedback, quality, exchange, awareness, illegibility, format, volume, cost, queries and out of date information could be eliminated by use of IT.

The chapter is concluded with a comprehensive review of literature to identify the most suited methodology to analyze productivity improvement and information availability in postwar construction that can be achieved with IS.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 OVERVIEW

Research is composed of two syllables, a prefix *re* and a verb *search*. *Re* means again, anew, over again. *Search* means to examine closely and carefully, to test and try, to probe. The two words form a noun to describe a careful and systematic study in some field of knowledge, undertaken to establish facts or principles. Research is an organized and systematic way of finding answers to questions. Research in common parlance refers to a search for new knowledge. Research can also define as a scientific and systematic search for pertinent information on a specific topic. This involves filling the knowledge gap of various discipline of knowledge area by careful investigation or inquiry through search. It follows certain steps that are logical in order. These steps are:

- I. Understanding the nature of problem to be studied and identifying the related area of knowledge.
- II. Reviewing literature to understand how others have approached or dealt with the problem.
- III. Collecting data in an organized and controlled manner so as to arrive at valid decisions.
- IV. Analyzing data appropriate to the problem.
- V. Drawing conclusions and making generalizations (Bryman & Bell, 2007).

This chapter reviews Research Philosophies and the theories behind Research. It justifies appropriate methodology to be implemented for this study. Having considered all the theories, case study method is selected as the main method for exploration. Selection of case study is also very well justified to reach unbiased and impartial outcome.

3.2 TYPE OF RESEARCH

Collis and Hussey (2003) argue that many different types of research can be classified according to its purpose, process, logic, and outcome. Classification of main types of research is tabulated as per the format indicated in the table.

Basis of classification**Type of research**

Purpose of the research

Exploratory, descriptive,
analytical or predictive research.

Process of the research

Qualitative or quantitative research

Logic of the research

Deductive or inductive research

Outcome of the research

Applied or basic research

Exploratory research: This type of research is conducted in the absence of previous research findings similar to problems being studied or in the presence of very few findings. Exploratory research is used principally to gain a deeper understanding of something aiming to look for patterns, ideas or hypotheses. The approach to research is very open and concentrates on gathering wide range of data and impressions. Case studies, observations, and historical analysis are the main techniques used in exploratory research, which provide quantitative or qualitative data or both. In other words research assess whether existing theories or concepts can be applied to the problem or new theories are to be developed.

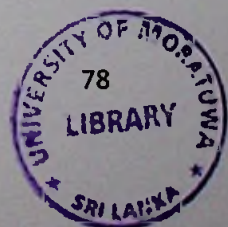
Descriptive research: Descriptive research describes data and characteristics of population or phenomenon being studied, as they exist. Outcome of descriptive research is more often quantitative and summarizing the information by statistical analysis is more convenient and well fitted. Examination of research problems moves further in descriptive research than exploratory research. Descriptive research encompasses much government-sponsored research including the population census, the collection of a wide range of social indicators and economic information such as household expenditure patterns, time use studies, employment and crime statistics and the like.

Analytical or Explanatory research: The goal of explanatory research is to answer the question of why and how. Explanatory research attempts to go beyond what exploratory and descriptive research analysis to identify the actual reasons a phenomenon occurs. This aims to understand phenomena by discovering and measuring causal relations among them and control the variables in the research activities to get a better explanation. In other words, it establishes a cause and effect relationship between two variables.

Predictive research: This goes further than explanatory research by establishing an explanation of likelihood of a similar situation occurring elsewhere. This research usually begins with finding what will happen, given that some baseline is already known and usually involves some form of human behavior decision or condition. Predictive research is aimed at, instead of explaining existing phenomena, predicting the future or new observations with high accuracy. In addition, solution to a particular problem in this study is applicable to similar problem elsewhere. Predictive research provides *how*, *why*, and *where* answers to current phenomena and similar events in the future.

Qualitative and Quantitative research: Quantitative approach is objective in nature and reality is singular apart from the researcher. Quantitative research is an inquiry into an identified problem, based on testing a theory, measured with numbers, and analyzed using statistical techniques. The goal of quantitative methods is to determine whether the predictive generalizations of a theory hold true. Qualitative approach is subjective in nature and reality is multiple as seen by different actors. A study based upon a qualitative process of inquiry has the goal of understanding a social or human problem from multiple perspectives. Qualitative research is conducted in a natural setting and involves a process of building a complex and holistic picture of the phenomenon of interest. Often the data presented from qualitative research will be much less concrete than pure numbers as data. Instead, qualitative research may yield stories, or pictures, or descriptions of feelings and emotions.

Applied and Basic research: Applied research refers to scientific study and research that uses its findings to solve specific practical problems. Applied research is used to find solutions to everyday problems. It is the type of research done with the intension of applying the results of the findings to solve specific problems currently being experienced in the organization. Basic research advances fundamental knowledge about the human world and improves our understanding of general issues. Basic research is the source of most new scientific ideas and ways of thinking about the world. Basic research generates a body of knowledge by trying to comprehend how certain problems that occur in the organization can be solved. It is done chiefly to enhance the understanding of



certain problems that commonly occur in organizational settings, and seek methods to solve them. It is called Basic or Fundamental, or Pure research.

Deductive and Inductive research: Deductive research work from broad spectrum of information to more specific conclusion, which is called top-down approach. The researcher begins with a theory about the topic of interest and narrows down into more specific hypotheses that can be tested to arrive at conclusion. Inductive research works opposite way from specific observation to broader generalizations and theories. This is called bottom up approach. In other words, theory is developed from the observation to empirical reality (Collis & Hussey, 2003), (Degu & Yigzaw, 2006).

3.3 PHILOSOPHICAL PERSPECTIVE OF RESEARCH

When undertaking research of this nature, it is important to consider different research paradigms and matters of ontology and epistemology. Collis and Hussey (2003) claim that there are two research paradigms or philosophies named positivistic and phenomenological paradigm. The equivalent terms in favor of held paradigms are depicted bellow (Collis & Hussey, 2003).

Positivistic system maintains that knowledge is about description rather than questioning. Positivists recognize only positive facts and observable events - those things that can be seen, measured and be counted as facts. The system equates very closely with the traditional, scientific view of the world. Positivism takes little account of beliefs or feelings, although strangely some of its extreme protagonists seem to be drawn towards mysticism. Positivism as a philosophy adheres to the view that only "factual" knowledge gained through observation, including measurement, is trustworthy. In positivism studies the role of the researcher is limited to data collection and interpretation through objective approach and the research findings are usually observable and quantifiable (Collis & Hussey, 2003).

Phenomenology is a very different way of viewing the world in comparison to positivism. Phenomenologists are concerned with what things mean, rather than with identifying and measuring phenomena. They are particularly interested in the idea that human experience

is a valuable source of data, as opposed to the idea that true research or discovery lies in simply measuring the existence of physical phenomena.

Positivistic paradigm	Phenomenological Paradigm
Quantitative	Qualitative
Objectivist	Subjectivist
Scientific	Humanistic
Experimentalist	Interpretivist
Traditionalist	Naturalist or Constructivist

Paradigms are the basic beliefs that lie behind and support legitimate inquiry.. Out of five paradigmatic assumptions, ontological, epistemological, axiological, methodological, and rhetorical, ontological and epistemological assumption governs the selection of research strategy.

Assumptions of Main Two Paradigms

Table 3.1: Assumptions of Main Two Paradigms

Assumption	Question	Positivist paradigm	Phenomenological paradigm
Ontology	What is the nature of reality	There is a reality that can be apprehended. Reality is objective and singular apart from the researcher and it is a concrete structure	The social actors construct realities and it is subjective. Multiple realities exist as seen by the researcher and only understood by examining perception of human actors
Epistemology	What is the relationship of researcher to that is being researched or how knowledge is acquired.	The researcher and the object of research are independent from each other and the object can be researched without being influenced by the researcher	The researcher interacts with the object of research and can affect that object. Findings are created through interaction between researcher and that is being researched

Axiology	What is the role of value	Values are excluded from the research process. They are considered confounding variables-phenomena that cloud our view of reality	Values have a privileged position. Often, there is a value-laden purpose to the research. The researcher is not reluctant to be openly passionate about pursuing the project
Methodology	What is the process of research	Deductive process cause-and-effect. Generalization leading to prediction, explanation and understanding. Accurate and reliable through validity and reliability	The meanings of the social actors can only be discovered through close interaction between the researcher and respondents. Inductive process. Accurate and reliable through verification
Rhetorical	What is the language of research	Formal based on set definitions. Impersonal voice	Personal voice. Use of accepted qualitative words

Source: (Collis & Hussey, 2003)

Above-mentioned two cluster of belief are extremes or boundaries of continuum of paradigms. The paradigm that the researcher adopts has a great importance for the methodology being used. However, like theories the methodology adopted cannot be true or false. Some may argue that one methodology is more appropriate for the phenomena under study than the other is, depending on the assumptions of researcher. Therefore, selection of best-suited paradigm mainly depends on realization of the theories behind these paradigms. Behavior and features of those two extremities of continuum polarizes as depicted below.

Features of Main Two Paradigms

Table 3.2: Features of Main Two Paradigms

Positivistic paradigm	Phenomenological paradigm
Tends to produce quantitative data	Tends to produce qualitative data
Uses large samples	Uses small samples
Concerned with hypothesis testing	Concerned with generating theories
Data is highly specific and precise	Data is rich and subjective
The location is artificial	The location is natural
Reliability is high	Reliability is low
Validity is low	Validity is high
Generalizes from sample to population	Generalizes from one setting to another

Source: (Collis & Hussey, 2003)

The use of a particular methodology for a research project depends on the scope, purpose, target population, etc. of the study as well as the resources available to the researcher. It is essential, that in order to achieve their objectives, researchers adopt the right methodology to achieve the research objectives and select the right data collection techniques through which they can collect the required data within their available resources.

Research studies are conducted for the purpose of obtaining data that is ordinarily not available from other sources regarding a specific area of knowledge. Obtaining empirical data can be done using many different techniques. The most common ones include interviews, observations, case studies and questionnaires. The method select depends on the goals and objectives of the research, the sample of respondents involved, the time set for the completion of the study, and monetary considerations (Kothari, 2006).

Collis and Hussey (2003) further states that research methodology directly correlates to the assumptions of research paradigm. Author has polarized research methodologies and positioned them in the two extremities of research paradigm as depicted below.

Methodological Assumptions of Main Paradigms

Table 3.3: Methodological Assumptions of Main Paradigms

Associated methodologies of positivist paradigm	Associated methodologies of phenomenological paradigm
Cross-sectional studies	Action research
Experimental studies	Case studies
Longitudinal studies	Ethnography
Surveys	Feminist perspective
	Grounded theory
	Hermeneutics
	Participative enquiry

Source: (Collis & Hussey, 2003)

Cross-sectional studies: This is a positivistic methodology intended to gather information on variables of different context. Information gathers from different organizations or different societies to ascertain how factors differ. Then researcher can conduct statistical analysis to figure out the correlation between variables. This analysis provide evidence whether correlation between variables exists or not but it will not present any evidence for reason for such existence. In the case of restricted time and resources for the study, cross-sectional studies are best suited.

Experimental Studies: These are also a positivistic methodology, which is conducted in laboratories or in a natural setting in a systematic way. This allows researcher to control one variable and observe the effect of other variables. This permits researcher to identify the causal relationship of variables.

Longitudinal Studies: These are also a positivistic methodology. The purpose of longitudinal study is to examine the characteristics of phenomenon over a period of time and compare changes occur with time.

Survey Studies: These are also positivistic methodology, which collect primary data from sample of subject selected from the population and then generalize behavior of sample

with the population. The most critical case is to select unbiased sample to represent characteristic of the population.

Action Research: Action research is based on the assumptions of the phenomenological paradigm that social world is constantly changing while researcher and research are part of it. Action research conducts within a single organization adopting similar procedure of case study approach. Action research is an applied research design used by to solve problems or supply useful information regarding educational policymaking and practice at the local level. Researcher actively involved and collaborating with practitioners while in case study research the researcher has a role of detached observer.

Case Studies: Case study research allows the exploration and understanding of complex issues. It is a robust research method particularly when a holistic, in-depth investigation is required (Collis & Hussey, 2003).

In addition to above mentioned paradigms the following listed are also frequently used in modern research.

- I. Ethnography
- II. Feminist Perspective
- III. Grounded Theory
- IV. Hermeneutics
- V. Participative Enquiry

3.4 SELECTION OF RESEARCH STRATEGIES

Having successfully completed the postwar reconstructions under "Eastern Revival and Northern Spring" programmes launched by the Government in 2009 military has been entrusted with development projects in various disciplines both public and private infrastructures around the country. Therefore, construction units/regiments in military have been compelled to explore all possible options as to how delivery of product could be achieved most efficient and effective way. Information technologies are an enabler to facilitate the improvements required for modernization of military construction style.

Hence, research carried out to evaluate the effect of information system in postwar reconstruction and construction under postwar scenario.

3.4.1 Case Study

In order to start with the research, addressing of research methodology aiming at research objectives is considered significant. Selection of research strategy includes research method as well as the logic behind the method used in the research study. As stated above conduct of research is guided by research paradigm comprising ontological, epistemological, axiological, methodological, and rhetorical assumptions that frame the nature of research, role of researcher, role of value, process of research and language of research. Under ontological assumption, this research holds realist perspective and there is a reality independently of the experience. This refers to the existing knowledge of information technology. This knowledge is local, provisional and context-dependent. Under epistemological assumptions, it refers to our theory of knowledge and how knowledge had been acquired (Bowden, 2005). Further Orlikowski & Baroudi (1991), cited in Bowden (2005) argues that most information technology research concentrated on technology and reflected positivist orientation (Bowden, 2005).

Past provides evidence that Information System history has been developed through Computing to Information Technology, Information Communication Technology, and Management Information Systems so on. This transformation incorporates number of disciplines, including computer science, management organizational studies, and social science, which tend information technology research to transform from positivist orientation to interpretivist orientation (Bowden, 2005). This means research paradigm transform from positivist to interpretivist or position between somewhere in extremes of the continuum. Keane and parent (1998), cited in Browden (2005) states that there has been shift of Information Technology away from technological issues to managerial and organizational issues which create opportunity for multiplicity of research approach (Bowden, 2005).

Before designing the research methodology, researcher need to get a clear idea of what is going to measure and framework for formulation of results. The focal point of this

research is to identify the effect of IS in postwar reconstruction and construction. This is a study of finding solution to problems faced by military when undertaking physical infrastructure constructions and attempt to answer the question of

- I. How can Information System deliver solution to problems faced by military in postwar Reconstructions Project Management?
- II. Why does deployment of Information System in postwar Reconstructions Project Management necessary?

To answer above questions, difference of contemporary phenomena and real life context of the research to be clearly identified. The boundaries between former and latter of this research are far apart and unfeasible to define. The contemporary phenomenon is the knowledge and the theories built around IT and construction industry as a whole. Real life context is the existing problems experienced by military personnel directly involved in physical infrastructure reconstruction and construction projects and those who manage such projects. The boundaries between two phenomena are difficult to distinguish or not evident.

Yin views the goal of case studies as understanding complex social phenomena, and real-life events such as organizational and managerial processes. He puts it– briefly– as follows:

"A case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context especially when the boundaries between phenomenon and context are not clearly evident" (Yin & Robert, 2009)

Case studies attempt to examine the "*how*" and "*why*" questions associated with an intervention. Case studies either describe or explain what happened in a particular case, by giving a detailed, holistic account of a particular case and allow researchers to see the product used in a natural setting (Benbasat, et al, 1987; Darke, et al., 1998; Yin, 1994, cited in Shakir, 2002). Further give evidence that Case study research is deemed suitable when the proposed research explore a contemporary phenomenon and addresses the "*how*" and "*why*" questions (Shakir, 2002). Further the phenomenon under study focuses towards contemporary knowledge of Information System, construction, reconstruction.

postwar reconstruction and reconstruction under military. Acquiring the knowledge and dependencies of this phenomenon cannot be studied in isolation due to interrelationship and interdependency of these phenomena. In other words it is a way of understanding the interaction between IT related innovations and organizational and environment context. Therefore it is evident that boundaries between contemporary phenomenon as well as real life context cannot be distinguished (Yin & Robert, 2009).

In some case studies, in-depth longitudinal examination of a single case or an event is used. In an event of single case, longitudinal examination real world problem is studied in detail by collecting data, analyzing information and documenting outcome over a long period of time. In addition, Case studies are considered useful as it enable researcher to assess in-depth examination of the real world context and analyze situation at micro level. Yin (1994, cited in bowden, 2005) defines case study "as a unique way of observing any natural phenomenon, which exists in a set of data". Mingers (2002, cited in bowden, 2005) states that "adopting a single approach is like viewing the world through a particular instrument such as a telescope, an X-ray machine, or an electron microscope". Methodology of this study lies between positivistic paradigm and phenomenological paradigm in the continuum and opening way for multiplicity of research approach is significant to deal with full richness of the real world problem. "Multiple method" research also known as "mixed method" research or triangulation is the act of combining several research methods to study single real world problem in a contemporary phenomenon, which offers the prospect of enhanced confidence. Olsen (2004) categorizes two types of triangulations as mixing of data or methods. The mixing of data types, known as data triangulation while mixing of methodologies, known as methodological triangulation that use more than two methods in studying the same phenomenon under investigation (Olsen, 2004). Nonetheless, Hussein (2009) defines four types of triangulations as depicted below (Hussein, 2009)

Data triangulation: This refers to gathering data through several sampling strategies or use of multiple data sources for validation purposes. This denotes to collecting data at different times and social situations, as well as on a variety of people. Denzin (1978, cited in Hussein, 2009) defines three types of data triangulation namely time, space and person.

Investigator triangulation: This refers to the use of more than one researcher in the field to gather and interpret data using multiple observers, interviewers, or data analysts in the field of study for confirmation purposes

Theoretical triangulation: This refers to use of more than one theoretical proposition in interpreting data. In other words, whenever researcher uses two approaches to collect data in the same study more than two methods are required to attain data validation within a single paradigm or else analyzing between two paradigms for completeness purposes.

Methodological triangulation: Mitchel (1986, cited in Hussein, 2009) explain methodological triangulation as use of more than one method (quantitative and qualitative) to investigate contemporary phenomenon within its real life context. Bums and Grove (1993, cited in Hussein, 2009) confirm this type of triangulation occurs at the level of research design or data collection. Denzin (1978, cited in Hussein, 2009) demystify two distinctive type of methodological triangulations; between-method and within-method triangulation. Between method triangulation uses quantitative and qualitative methodology to examine single phenomenon in two paradigms creating paradigmatic connection. Within-method triangulation uses quantitative and qualitative data to analyze the situation under same phenomenon to ensure internal consistency (Hussein, 2009).

As illustrated earlier in the literature review research problem encompasses knowledge of information technology, construction industry, PM and postwar situation and investigating the effect of information system in postwar reconstructions. The contemporary phenomena under study are information system and other real life phenomenon mentioned above. Orlikowski and Baroudi (1991, cited in Darke, et al. 1998) stress that case study research is a most widely used phenomenological approach in IS research (Darke, Shanks, & Broadbend, 1998). (Benbasat, et al., 1987 and Lee, 1989 cited in Darke, et al., 1998) stress case study research has been proposed as a valid means of testing theory within information system research (Darke, Shanks, & Broadbend, 1998). Shakir (2002) further confirms that Case study research is a more appropriate approach to study of IS implementation, especially when context is important. The value of single case research is methodologically viable in the study of critical cases whereas

the multiple case study approach is believed to be more appropriate to the study of typical cases of IS implementations (Shakir, 2002). Case study is now accepted as a valid research strategy within the IS research community (Klein & Myers, 1999).

Whatever the research method used, there are pros and cons of each methods used to investigate the phenomena. United Nations Conference on Trade and Development discusses merits and deficiencies of the case study approach as tabulated bellow (Young, 2007).

Table 3.4: Merits and Deficiencies of the Case Study Approach

Merits	Deficiencies
Provides in-depth and holistic perspective Multi-faceted; can show different perspectives	Time-consuming and expensive to administer
Can show how processes work over time and give insights into cause and effect	Bias of both the recipient (researcher) and supplier of information
Can serve both exploratory, descriptive and explanatory purposes	Data can be too rich, broad and complex to be analyzed
Can be used alongside statistics and other data and reports	Data analysis depends strongly on the analytical skills of the researcher
Well suited to international business research where cross-border and cross-cultural settings increase complexity	Particularly difficult to analyze when dealing with rich and complex data
	Limited generalizability; not representative of entire populations

Source: (Young, 2007).

3.4.2 Interview

Interviewing is a way of collecting data by talking to customers, clients or expertise that have the special knowledge about subject matter in order to gain insight to real world problem. This enables the researcher to gain practical experience with gathering data from a primary source. Interviews allow people to convey to others a situation from their own viewpoint and in their own words.

Though researches look like absolute different from research to research, they have some commonalities. One of the most essential facets is data collection. Interview is one of the most popular methods for collection of data. Interview also can be placed in a continuum, which can be identified as unstructured and structured at extreme ends (Public Service Commission , 2009). Some defines that there are three types of interviews as structured, semi-structured and unstructured.

Unstructured Interview; as a rule, unstructured interviews are used to explore new ideas when the phenomena under study is not understood or well known. This allows interviewee to express ideas freely with minimal control over the interviewer.

Semi-Structured Interview; In contrast to unstructured interview semi-structured interview does not allow interviewee to express ideas freely and interviewer has some controlled over the questions. It is based on prescribed questions called interview guide imposing some limitations to interviewee's freedom.

Structured Interview; In this type of interview, fully worded questions are developed according to the information to be acquired from the interviewee. Same set of questions are asked from other interviewees in the same way with the same probes. This facilitates cross - comparison of answers of other interviewees. Structured interviews are best used when a lot of information about the topic is already known (Rugg, 2010).

3.5 SELECTION OF CASE STUDY

Case study being the most appropriate approach to study of IS implementation and intended to be the reality check of contemporary phenomena in the real world context selecting the right project or projects for case study approach is a most significant task to achieve richness of data. Failure to select the most appropriate case will divert the exploration away from the reality producing less reliable outcome. The task of selection appropriate set of projects is more challenging due to limited resources, period allocated for the entire dissertation, dynamic changes in construction environment. Selecting projects based on the convenience of the researcher without comparison to other factors such as nature of project and its magnitude, multiplicity of engineering discipline

involved, state of construction during the time of investigation may end up in insignificant results without aligning to the research strategy.

Military of Sri Lanka is presently undertaking ample of projects in varying construction disciplines, financial limits, geographical locations and project-funding agencies extending from minor level to mega level constructions. The preliminary selection criteria was placed based on magnitude of the cost of project with an assumption that higher the project cost greater the involvement of engineering disciplines, amount of work and managerial problems.

Therefore twelve major projects anticipated costing over LKR 300 million out of other projects scattered around the country, which are presently being undertaken by Defence Services of Sri Lanka, are considered for case selection. It is evident that almost all the constructions project entrusted to military are building construction except very few cases of other specialties like playground and swimming pool.

Table 3.5: Major Construction Projects Undertaken by Military

Sr No	Project Name	Project Cost (LKR Billion)	Date of Commence	Date of Completion	% Complete	Deployment Officers X Tradesmen
01	Defence School - Colombo -SLA	1.5	06.03.2006	31.01.2013	96%	03x450
02	Mahinda Rajapaksa ISC – SLA	1.1	20.03.2010	13.09.2013	40%	04x480
03	Millitary Hospital Complex- -SLA	2.0	18.04.2010	18.04.13	60%	06x450
04	Dutch Building - Colombo - SLN	0.4	01.02.2011	01.12.2012	95%	01x120
05	Colombo Rugby Ground - SLA	0.5	25.03.2011	31.05.2013	80%	03x450
06	Sports Ministry – SLA	0.5	03.05.2011	14.04.2013	70%	02x225

07	Medical Faculty Complex KDU – SLA	1.6	20.05.2011	20.12.2013	60%	02x225
08	Defence School - Kurunegala – SLN	0.3	04.08.2011	31.12.2012	60%	01x150
09	Holiday Resort Yala - SLA	0.3	15.11.2011	15.12.2012	30%	02x150
10	Galle Center Colombo - SLA	0.35	25.01.2012	25.06.2013	60%	01x480
11	SARC Cultural Centre Matara – SLA	0.8	21.04.2012	21.12.2014	50%	03x150
12	DHQC - Akuregoda - Tri Service	39	23.04.2012	23.10.2015	15%	215x4800

It is clear that following factors govern the criteria for selecting most fitting case

Criterion A Project cost

Criterion B Project cost versus duration

Criterion C Percentage of work completed at the time of investigation

Criterion D Specialties involved in the project

Analysis of a Complex and a Large Construction Project is desirable since it will cover all the major complexities during the research. Selecting a complex project will result in an analysis of a project, which is with a big budget, complex and longer duration, huge resource usage, considerable staff and specialties involvement. Further the analysis will be comprehensive including the inputs of specialized staff and expertise.

A researcher has derived that a comprehensive analysis, projects that are over 80%, are not desirable. The reasons are lack of proper data and documentation, not defining a proper WBS, lack of integration with the WBS, etc. In other words, he has suggested selecting projects, which are comprehensive with documentation and planning for a better analysis. Factors based on Lukas's study are used in this research to make sure the case study selection is optimized and below individual factors have been analyzed thoroughly. (Lukas, 2008).

Criterion A - Project cost; Project cost is measured as the monetary value/cash associated with a particular project. In construction industry, cash is the main engine of the organization. In most situations, higher the project cost greater the involvement of engineering disciplines, amount of work and managerial problems. For generalization of evidence of one situation to another situation without further study of validity in a new situation higher valued project seems more appropriate.

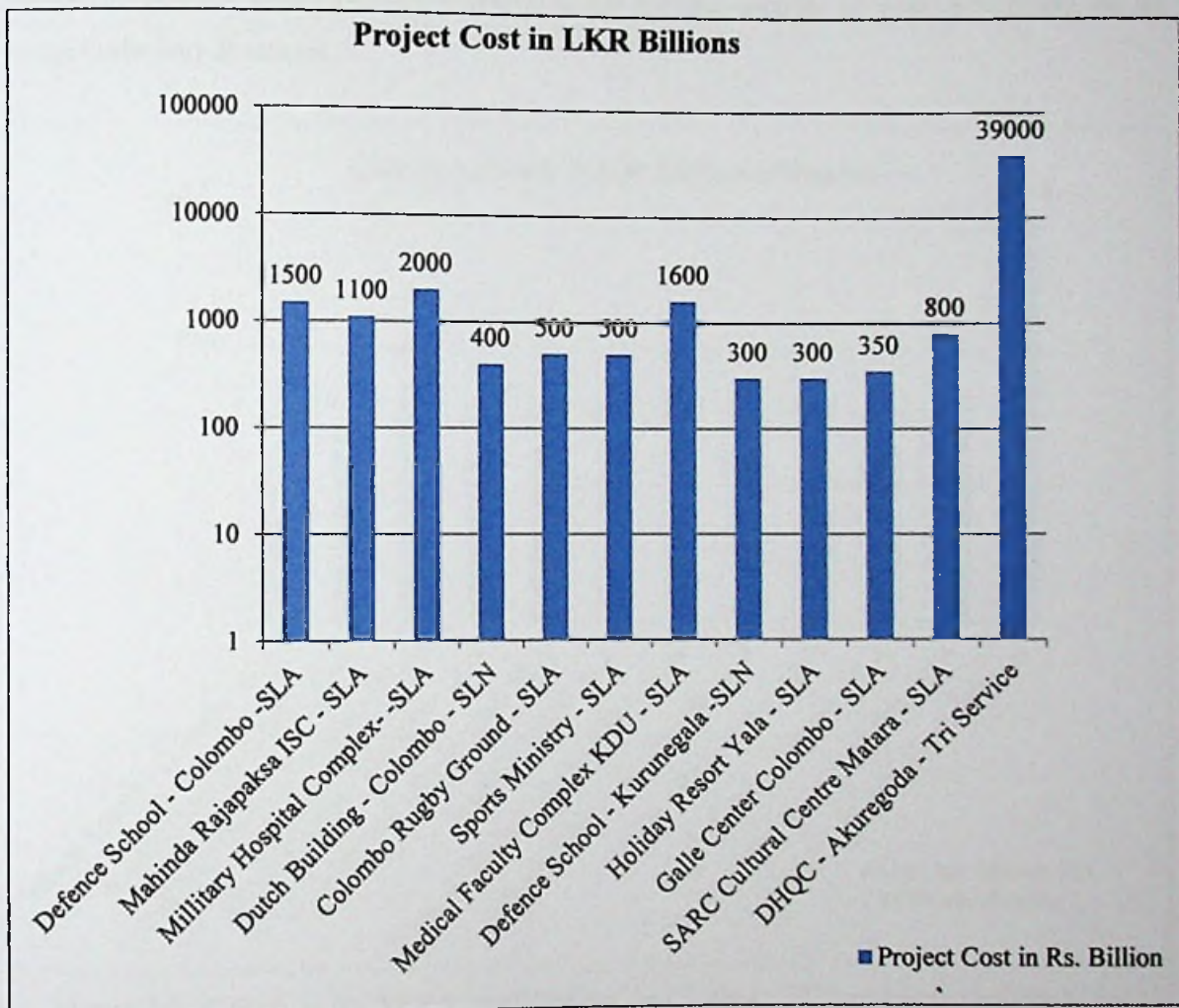


Figure 3.1: Criterion A - Project Cost

Considering above facts three highest value projects Military Hospital Complex-Colombo-SLA, Medical Faculty Complex KDU SLA, DHQC - Akuregoda - Tri Service consider for case selection under Criteria A.

Criterion B - Duration of project and value of work to be done in unit time; Cost, duration, specialties involvement and labour deployment of projects are correlated and

interdependent parameters which apply throughout the project life cycle. When the duration of a particular project increases within constant work scope it reduces amount of work to be done during specific period. It also affects to the amount of various specialties involvement of the particular project during that period. In other words, it is of paramount importance to consider higher value project cost schedule to complete within shorter period to do holistic in-depth investigation. This is a quantitative measurement, which is measured against time (average work done per month, quarter or year depending on its magnitude and duration).

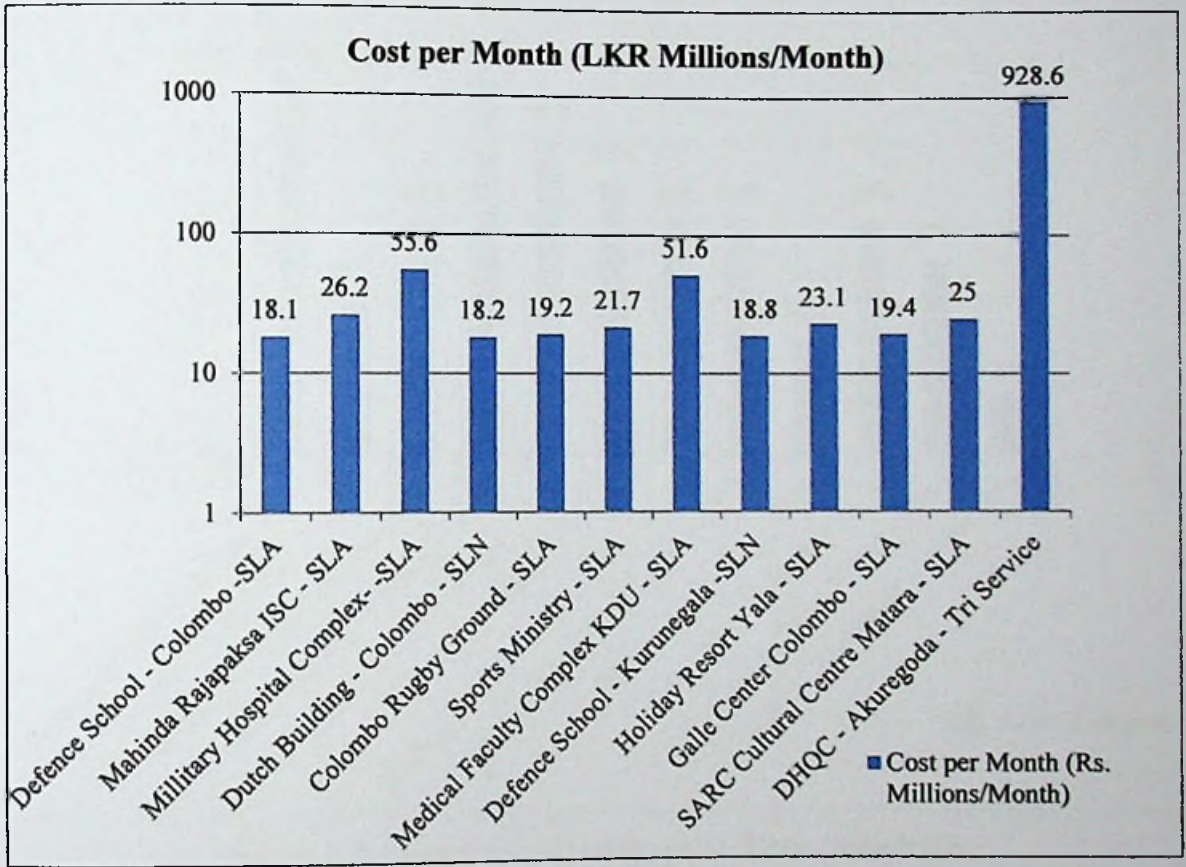


Figure 3.2: Criterion B - Duration of Project and Value of Work Done in Unit Time

Criterion C - Percentage of work completed; there are two fields that are defined as percent complete and percent work complete. Percent Complete is a measure based on duration and Percent Work Complete is based on work. These two fields are calculated as follows

$$\text{Percent Complete} = \text{Actual Duration} / \text{Duration}$$

$$\text{Percent Work Complete} = \text{Actual Work} / \text{Work}$$

It is observed that almost all the postwar infrastructure construction projects entrusted to military had been building construction except very few cases of other specialties like playground, swimming pool, irrigation systems and roads. Therefore, percent work complete to be evaluated to investigate behavioral aspect of building construction projects.

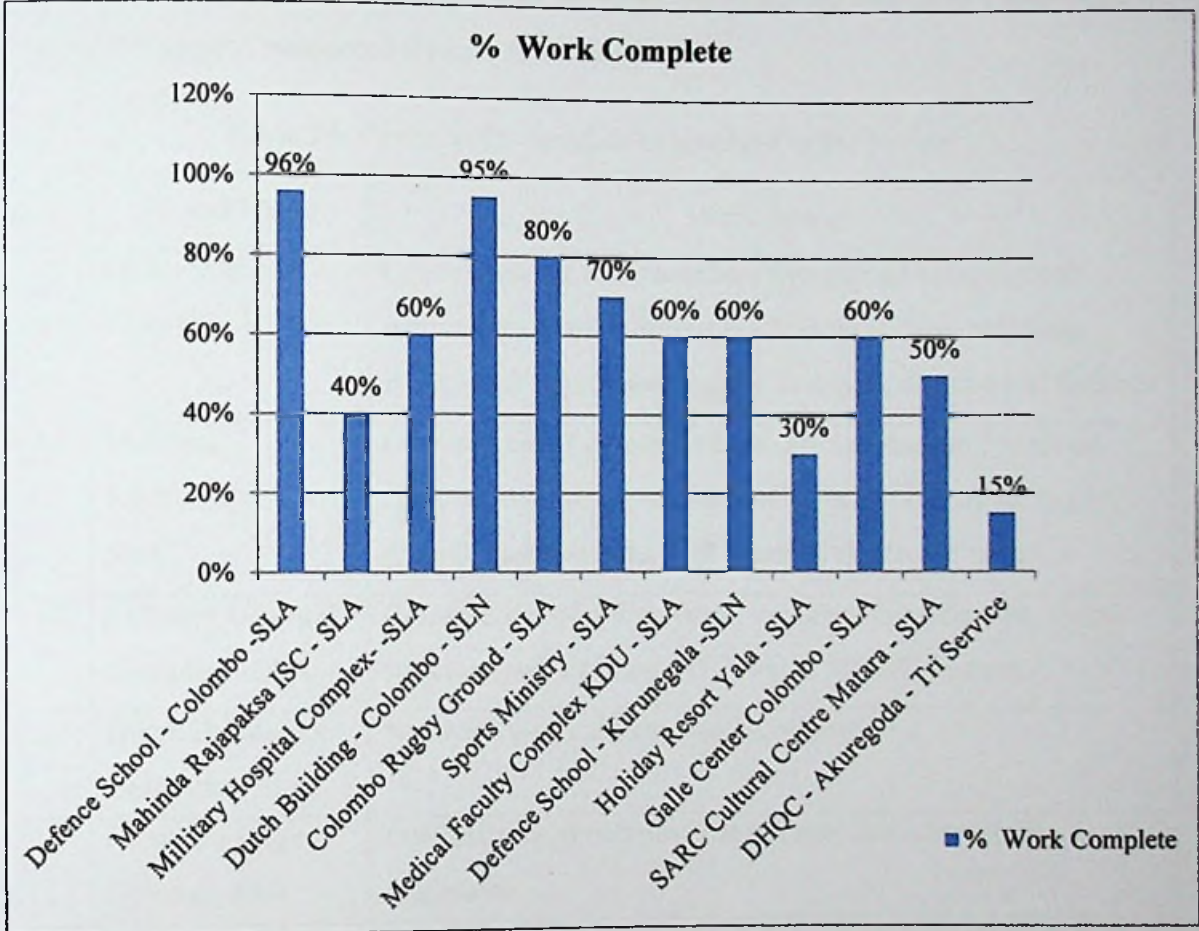


Figure 3.3: Criterion C - Percentage of Work Completed

When projects operate at the last lap of its life cycle it is obvious that challenges ahead is minimal and consideration of those projects is not worthwhile. In contrary just started projects also do not create richness of data as the period of data investigation has limitations. Cost and performance prediction should be valuable during the early stages of a project. Hence project having physical percentage complete in between 10% to 50% is more suitable for the study (Aziz, 2007). Hence, three projects named Mahinda

Rajapaksa ISC - SLA, Holiday Resort Yala - SLA, and DHQC - Akuregoda - Tri Service that lie percentage of work completed within the defined regions are selected.

Criterion D - Specialties involved in the project

Under this situation, outline below illustrates work scope and specialties involved against respective project considered for case selection.

Table 3.6: Criterion D - Specialties Involved in the Project

Sr No	Project Name	Work Scope
01	Defence School - Colombo -SLA	Construction of three numbers five storied building and renovation of two numbers old buildings. new buildings include raft foundation, supper structure, dry and wet finishes
02	Mahinda Rajapaksa ISC - SLA	Construction of indoor stadium, cricket stadium, hospital complex, swimming pool complex, athletic ground, rugby ground, baseball field, VIP Chalets, electronic range.
03	Millitary Hospital Complex- -SLA	Construction of pilling work, concrete sub structure, supper structure. wet finishes, MEP work, MVAC System
04	Dutch Building - Colombo - SLN	Renovation of existing Dutch building
05	Colombo Rugby Ground - SLA	Construction of two pavilions to accommodate 4000 spectators.
06	Sports Ministry - SLA	5 Storied new building with offices including office for Minister of Sports.
07	Medical Faculty Complex KDU - SLA	Concrete sub structure, supper structure. wet finishes, MEP work, MVAC System
08	Defence School - Kurunegala -SLN	Construction of multi-storied class room and administration building.
09	Holiday Resort Yala - SLA	3 Storied two rooms 10 Nos blocks, swimming pool, restaurants to accommodate 250 personals

10	Galle Center Colombo - SLA	Renovation of existing building (old fish market in Colombo). Converting portion of building to shopping complex.
11	SARC Cultural Centre Matara - SLA	6 stories building complex within 5 acre land area, MVAC system, fire detection system.
12	DHQC - Akuregoda - Tri Service	Piling work, raft foundation, concrete sub structure, supper structure. wet finishes, dry finishes, MEP work, MVAC system, BMS, security systems

Selected projects using the four Criteria Specialties involved in the project are tabulated below to evaluate the most suitable case.

Table 3.7: Summary of Criteria

Situation Project	Military Hospital Complex -Colombo- SLA	Medical Faculty Complex KDU - SLA	DHQC Akuregoda- Tri Service	Mahinda Rajapaksc ISC - SLA	Holiday Resort Yala - SLA
Criterion A	ok	ok	ok	-	-
Criterion B	ok	ok	ok	-	-
Criterion C	-	-	ok	ok	ok
Criterion D	ok	-	ok	ok	-

For selection of case study, involvement of different fields of engineering within engineering technology is considered as selection criterion. Building construction industry involves Civil, Mechanical, Electrical, Electronic Engineering and ICT as well. Out of twelve projects Military Hospital Complex-SLA, DHQC - Akuregoda - Tri Service and Mahinda Rajapaksa ISC - SLA have the maximum involvement of different specialties. Construction of Defence Headquarters Complex-Akuregoda undertaken by Tri-Services fulfills conditions stipulated in all four Criteria. Hence, this project is the most suited for case study.

3.6 SELECTION OF INTERVIEWEES

Interviewing is a way to collect data as well as to gain knowledge from individuals called interviewees. The purpose of this interview is to enhance the validity and reliability or reconfirm the validation of data gather from selected case study. It is therefore essential to select the best-suited individuals who are capable of providing valuable information of contemporary phenomena under investigation. In other words, individuals those who process PM skills viewing in broader aspect, experience in postwar reconstructions, and PM Skills under heavily militarized situation. Therefore, interviewees are selected under three categories

Category A - Good PM Skills.

Category B - Experience of PM in Postwar Reconstructions

Category C - Field Experience of under Heavily Militarized Situation

Category A - Good PM Skills; Good PM Skills develop in a person from myriad of disciplines. In broader perspective, some skills come from human behavior and others from technical background of the person. Some of the skills are learned through experience of success and failure factors of projects. Clarizen 2012 defines combination of proficiencies converge to success of the project manager which include personal, management and technical skills.

Personal Skills

- I. Teamwork - knowing how to listen, share, cooperate and learn together as a team
- II. Positive attitude - important for difficult times incurred along the way throughout the process
- III. Ability to clearly articulate expectations - clearly define what is expected of team members
- IV. Manage by example - project managers must be straightforward and knowledgeable in all dealings.

- V. Be direct and unbiased - Expectation of delivering project fulfilling triple constraints of PM.

Technical Skills

- I. Technical knowledge and skills required to complete the project.

Management Skills

- I. Critical thinking
- II. Decision-making
- III. Negotiation
- IV. Growing and sustaining a high performing team
- V. Managing budgets, costs and expenses of the project
- VI. Project execution and control (Clarizen, 2012).

Any professional expertise in planning, investigation, design and construction supervision works of various engineering specialties such as building construction, hydropower plants, water resource management and roads, railway lines and bridge construction will have most of above-mentioned skills. Selecting professionals from an organization dealing with multidisciplinary engineering constructions is a way forward to gather data that are more accurate. Unlike in other Asian countries very few organizations in Sri Lanka have in-house expertise in different engineering disciplines. Central Engineering Consultancy Bureau established in 1973 under Ministry of Irrigation and Water Management is a leading organization in construction industry of Sri Lanka that actively involved in consultancy and construction in various engineering disciplines. Hence, Central Engineering Consultancy Bureau being a leading, highly diversified, multidisciplinary engineering consultancy and construction organization is the most suitable for selecting professionals for the interview. On that basis one very senior professional from Central Engineering Consultancy Bureau who command good PM Skills presently acting as effective managers and advisers in Sri Lankan construction industry are selected for the structured interview.

Category B - Experience of PM in Postwar Reconstructions; Sri Lanka Civil War destroyed infrastructure, generated large-scale human suffering, created refugees, and displaced populations. In broader perspective rehabilitation and reconstruction of social and economic infrastructure in a postwar environment is complex. Repairing war-damaged infrastructure in order to reactivate the local economy was a big challenge for GoSL. Planning and implementing reconstruction projects in areas affected by conflict has proven to be far more challenging than expected. As an immediate remedy GoSL entrusted some of the infrastructure rebuilding to military being one of the government organization rich with work force and machinery resources. That was another new barrier for military to face specially for Sri Lanka Army to whom major portion of work entrusted. Military took a decision on management of those projects to successful completion through central hubs of military headed by directors of engineering proficiency. High rank officers of Directorate of Engineering of Tri-Services involved in resettlement and reconstructions programmes. The PM skills of directors of Tri-Services developed during war situation through infrastructure developments programmes launched to meet rapid expansion of corps of military tremendously helped to maneuver entrusted task to success. Therefore, two senior officers from Directorate of Engineering of Sri Lanka Army and Sri Lanka Navy will be interviewed to share their experience for within-method triangulation.

Category C - Field Experience of PM under Militarized Situation; Soon after the defeat of LTTE GoSL began to restore Northern and Eastern provinces to normalcy. Having identified the difficulties of undertaking restoration at national and provincial capacity due to lack of resources high powered Presidential Task Force appointed by GoSL decided to assign military officials to coordinate with other institutes, United Nations & Partners for expeditious resettlement and immediate restoration. The biggest challenge for the GoSL was resettlement of nearly 350,000 people in welfare centers. The entire resettlement programme was handled through mechanism of Ministry of Resettlement, Presidential Task Force, Government Agents and Sri Lanka Army. (Government of Sri Lanka, United Nations & Partners, 2011). Construction of physical infrastructures required to fulfill basic need of human beings in welfare centers managed by Sri Lanka Army Engineers. In addition to reconstruction and construction launched under North

Spring and Eastern Revival programmes more reconstruction and construction projects in other provinces were also delegated to military.

Under these circumstances, military personnel directly involved in resettlement and reconstruction programmes in Northern and Eastern provinces and those who involved in reconstruction and construction projects in other provinces are interviewed.

Under category "A" following professional who command good PM Skills presently acting as effective managers and adviser in Sri Lankan construction industry is selected for the structured interview.

Eng. CS Soysa - Ex - General Manager
Central Engineering Consultancy Bureau

Under category "B" Directors of Sri Lanka Army and Sri Lanka Navy who contributed tremendous effort to reconstruction programmes undertaken by military at the height of war and postwar situation are selected.

Rear Admiral WS Jayasinghe - Director General Civil Engineering
Naval Headquarters
Colombo

Brigadier Jayasundara - Director Engineering Services
Sri Lanka Army Headquarters
Colombo

Under category "C" officers of Sri Lanka Army involved in resettlement and reconstruction programmes in Northern and Eastern provinces and other two officers involved in reconstruction and construction projects in other provinces are selected.

Commodore (CE) D Liyanage- Director Civil Engineering
Naval Headquarters
Colombo

Brigadier KAPJ Rathnayake - Project Manager (Engineering)
DHQC Project Akuregoda



Colonel P Gunasekara

-

Commanding Officer

6th Engineer Service Regiment

Malay Street

Colombo

The research philosophies that exist in the field of research are briefly discussed. The suitable research philosophy is justified and according to that, this chapter identifies the sample for case study. In order to establish the impact of IS to enhance efficiency of postwar CPM, ERP system for Defence Headquarters Project Akuregoda, Battaramulla is deployed.

The professionals chosen through the criteria defined above will be scrutinized with the following aspects in order to obtain an insight for the data analysis.

First, they will be reconnoitered for their experiences and expertise in PM and the most difficult aspects of CPM. Secondly, the involvement towards reconstruction or military construction projects will be analysed. Most importantly, the barriers will be identified. The third aspect would be to capture their perspective on distributed PM Systems. The theoretical benefits and the practical aspects will also be looked in to for better analysis. The fourth and the last area would be to get a comprehensive feedback after reviewing the ERP system, which will be having some key data. In addition, thorough demonstrations on key processes, which directly influence the efficiency of PM, will be referenced for expert feedback.

3.7 SUMMARY

Chapter 3 consists of the Research Methodology and Research Philosophies considered for the study. Research Philosophies and the theories behind Research has been reviewed in this chapter and the appropriate methodology has been selected after justifying the type of research this study consists.

Having considered all the theories mentioned and reviewed in the chapter, case study method is selected as the main method for exploration. However the presence of multiple actors (end user, project team, service provider) within multiple organizations and need to

address multiple aspect (problems encountered by military, cost, usability, possess and benefits) multi-methodology under same research paradigm called within - method is best suited to deal effectively with the real world problem. Therefore single case study, which is quantitative approach and structured interview, which is qualitative, will triangulate the phenomena to create richness of outcome.

The chapter discusses methodology for selection of case study, which is based on four Criteria.

- I. Criterion A Project cost
- II. Criterion B Project cost versus duration
- III. Criterion C Percentage of work completed at the time of investigation
- IV. Criterion D Specialties involved in the project

Only one project, DHQC - Akuregoda undertaken by Tri Service Construction Team satisfies all four conditions. Hence Construction of Defence Headquarters Complex Akuregoda is selected for the case study.

To choose the best-suited group of interviewees, three criteria analysis are used.

- I. Category A - Good PM Skills
- II. Category B - Experience of PM in Postwar Reconstructions
- III. Category C - Field Experience of PM under Heavily Militarized Situation.

Based on the above criteria several professional experts were chosen out of a sample. In a summary, the chapter is concluded with a comprehensive identification of Research Methodologies to move forward towards the data collection and analysis.

CHAPTER 4 - ANALYSIS

4.1 OVERVIEW

This chapter contains the data analysis in order to obtain accurate research output. The benefit of Information Technology adoption for postwar reconstruction and construction to develop economic state of war torn communities were identified from literature and after interviewing experts from the construction industry as well as in the military. The data collected from various sources have to be arranged in a methodical way to build the case, which ultimately results in the research output. The analysis is carried out by deploying a test model of web based ERP system of M/S Sapere (Pvt) Ltd to DHQC project of Akuregoda, Battaramulla. The reason for selection of DHQC project for the case study out of twelve main projects undertaken by military at the time of writing the methodology were lengthily discussed under chapter 3.5 (selection of case study). Therefore, background of DHQC project will be discussed here prior to focus on data analysis.

4.2 BACKGROUND OF THE DHQC PROJECT

Colombo master plan of 1979 was featured moving all government buildings and offices out of Colombo to the adjacent administrative capital of Sri Jayewardenepura, Kotte. Proposal was also made to develop that the neighboring city of Battaramulla as an administrative hub. Under Colombo Development Plan, prominent landmarks occupied by government department are to be relocated out of Colombo. Therefore, six acres of government land facing the Galle Face green promenade, a prominent landmark in Colombo, Sri Lanka occupied by the Sri Lanka army headquarters which was moved temporarily to another location in Colombo were sold to Hong Kong-based Shangri-La Asia Limited. Shangri-La has begun construction work on its first hotel in Sri Lanka, which is experiencing a boom in tourism after the end of its 30-year ethnic war.

Under the guidance of His Excellency the President, the Commander in Chief and the Secretary to the Ministry of Defence the vision of creating a composite administrative complex for the Defence establishment was implemented. The aim of such was a centralized organizational structure that would develop corporation and understanding

amongst the Tri Forces, whilst enhancing efficiency through the sharing of resources within the Defence hierarchy.

In a Cabinet Memorandum dated 04 of January 2011, the Ministry of Defence, in Sri Lanka, proposed the Relocation of the Ministry of Defence, Office of the Chief of Defence Staff and the Headquarters of the Armed Forces to Akuregoda, Battaramulla. Under the proposed relocation, an amalgamated Office Complex is to be established for the Ministry of Defence (MoD), Office of the Chief of Defence Staff (OCDS) and the Headquarters of the Armed Forces of Sri Lanka (Tri Forces), including the SL Army (SLA), SL Navy (SLN) and SL Air Force (SLAF).

Establishment of a Central Defence Headquarter Complex project was coming under and land area surrounded by old SLAVF headquarter complex is selected for the construction. This land is located in Pelawatta; Battaramulla bounded by Akuregoda road. The above-mentioned land collection consists of nearly 10 land lots of different landowners. Among this all, largest land lot was previously known as St Ives watta, which located opposite side of old SLAVF headquarter complex. Total land area of the lot is about 52 acres, which earlier belongs to Airport and Aviation Services (Sri Lanka) Ltd. Opposite to St Ives Watta, 04 land areas were acquired to the project named Thalakumbura, Diyakaduweniya Kumbura, Weve Kumbura and Batadombagaha Kumbura with 07 allotments.



01 - Main Building 02 - Communication Tower 03 - Security Building 04 - ORS Mess 05 Officers Mess
 06 - Ceremonial Access 07 - Staff Access from Akuregoda Road 08 - Pannipitiya Road 08 - Staff Access



Figure 4.1: DHQC Project Plan

In 2010, Ministry of Defence and Urban Development transferred the ownership of St Ives watta to Urban Development Authority. Rest acquired by paying compensation for respective landowners.

The new Defence Headquarters is to house the ministry of Defence, Headquarters of the Tri services, office of the Chief of Defence Staff, the offices of the Commanders of the three armed forces, training centers, operational rooms, research centers, and other facilities.

4.2.1 Rationale for Establishment of DHQC Construction Organization

The Construction industry is one of the key industries that can put any country on the fast track of development. For the first time it became a major contributor to the country's economy by showing a 17.3% growth in 2011 which is a record. It has been revealed that military's involvement in reconstruction and construction during postwar scenarios has contributed immensely to the country's socioeconomic development. Military initiative to the Sri Lankan construction industry became an upward trend.

DHQC would be a millstone of Sri Lankan construction industry. It considered as the largest building project by value ever proposed in Sri Lanka, using military workforce. Apart from numerous challenges, stemming from a variety of sources, faced by implementing agency of construction industry in Sri Lanka military's main concern is lack of professionals who had managed construction projects of mega scale. Military alone cannot undertake a project of this magnitude without the professional advice from outside agencies or individuals who are capable of providing assistance to military to achieve project success.

Since this being a project of the largest magnitude and involvement of myriad of complicated construction methodology Tri-Services need to maintain higher degree of efficiency with a view to enhancing performance and productivity. This directly helps for capacity building of military personnel, which would be an immense advantage to move military forward in par with Sri Lankan construction industry in future. Therefore, establishment of robust organization comprising outside expertise personnel to face the challenges in implementing the proposal is considered significant.

4.2.2 Organizational Framework

It has long recognized that good PM capacity is necessary for project success. To harness such capacity, when regular staff would not be available for PM, or would need to be assigned full-time and thus taken away from other duties most projects have used special units to manage project implementation depending upon the nature of the tasks.

To manage a project, the authority has to set up a project organization, which can supply the resources for the project and service during its life cycle. It has identified three main types of project organizations:

- I. Functional
- II. Matrix
- III. Project or task force

From a project manager's point of view projectized or task force organization is the ideal type of project organization, since with such a set up project manager has complete control over every aspect of the project. The project team will usually be located in one area. Lines of communication are short and the interaction of the disciplines reduces the risk of errors and misunderstandings. Not only are the planning and technical function parts of the team but also the project cost control and project accounting staff. This places an enormous burden and responsibility on the project manager, who will have to delegate much of the day-to-day management to special project coordinators whose prime function is to ensure a good communication flow and timely receipt of reports and feedback information from external sources. Not only is the project manager concerned with the technical and commercial aspects of the project, but has also to deal with the staff, financial and political issues, which are often more difficult to delegate.

Having identified the functions, duties, objectives, activities, staffing levels, job descriptions and performance management system of the construction process, the structure of DHQC construction organization which often seen as a temporary organization representing Tri Services are designed to meet challenges encounter during the life cycle of the project. The structure consists of three portfolios; Steering Committee

(SC), PMU where head of the PMU will act as project manager of the whole project and Construction Management CMU.

Steering Committee

The steering committee consists of senior dignitaries headed by Secretary to the Ministry of Defence and Urban Development (MOD &UD) assisted by Additional Secretary (Technical) and Chief of Defence staff (CDS) and the Commanders of Army, Navy and Air Force.

Project Management Unit

PMU consists of professional staff in various disciplines of construction industry. M/S Muditha Jayakody Associates (Pvt) Ltd jointly with LACE PL and Central Engineering Consultancy Bureau meet client's expectations and thus to achieve successful completion of project in specified time at projected budget to the required quality standard. PMU comprises of following functional teams of different specialties.

- I. Senior Advisers (Civil Engineering, Mechanical Engineering, Electrical and ICT Engineering)Project Manager (Audit)
- II. Director (Procurement and Finance) and Project Managers of Procurement and Finance.
- III. Project Manager (Mechanical Engineering)
- IV. Project Manager (Electrical and ICT)
- V. Project Manager (Planning and Scheduling)
- VI. Project Manager (Health and Safety)
- VII. Project Manager (Administration and Logistic)
- VIII. Project Manager (Technical & Services)
- IX. Project Manager (Civil Engineering)
- X. Project Manager (Environmental and Social affairs)
- XI. Project Manager (Design Coordination)

In addition to the specialist advices seek from outside Agencies or individuals involvement of personnel specialized in the stream of Civil Engineering, Mechanical

Engineering, Electrical and ICT Engineering, Highway Engineering, Architectural, and Quantity Surveying will be of vital importance in achieving the project goal. Available professional staff in Tri-Service is not sufficient to cater all specialist services mentioned above without compromising ongoing postwar reconstruction and construction projects and other physical infrastructure development programmes undertaken by military. Therefore, outside professional services may be required to fill some appointments of functional teams.

Construction Management Unit

CMU is established to undertake construction work of Defence Headquarters Complex using military personnel who possess high degree of both practical and theoretical knowledge of their respective trades. For achieving above milestone structure of CMU is designed with following main functional teams.

- I. Director CMU
- II. Project Manager Construction SLA
- III. Project Manager Construction SLN
- IV. Project Manager Construction SLAF
- V. Project Manager Electrical and Mechanical
- VI. Project Manager Plant and Machinery
- VII. Project Manager Construction Support
- VIII. Quality Manager
- IX. Stores Manager
- X. Medical Officer
- XI. Security and Provost Officer

(PMU, 2012)

4.3 RELIABILITY OF DATA

It is very important to consider reliability and the validity of data collected for analysis to achieve better outcome. The reliability of data directly relates to position and the experience of selected professionals for interview and data entered in web based ERP system of M/S Sapere (Pvt) Ltd.

Project selected for the case study commenced immediately after the defeat of LTTE by the Sri Lankan Government on 19 May 2009 that the war lasted almost 26 years, which have caused displacement of 1.1 million people and claimed 150,000 lives. Many consider this project as not only the largest postwar building construction project of Sri Lanka but also the biggest footprint of a building ever constructed in Sri Lanka. Therefore, DHQC project makes various data available for analysis of effect of information system of postwar reconstruction and construction through a case study.

All the interviewees are falling into the experience category of positively involvement in construction industry of 20 to 32 years in difference disciplines occupied in civil engineering construction work that deals with the design, construction, and maintenance of the physical and naturally built environment, including works like roads, bridges, canals, dams, and buildings. They are in the possession of high levels of knowledge and well aware of the complicatedness of managing projects fluctuating from small Enterprises to Small Medium Enterprises.

The identified variables and perceived benefits in this research categorize under four groups, which recognized from the literature. The first is benefits related to measures of project success; second effective team management; third effective use of technology for construction and the last increased organizational efficiency to gain maximum benefits for effective PM.

4.4 DATA GATHERING

Preliminary earthwork of DHQC project commenced early 2011, continued until incorporate modifications and improvements to architectural drawings, and schematic design of architectural drawings. Prior to complete design development drawings raft foundation began on 27th April 2012 on completion of and structural design of one tower block of foundation using details of schematic drawings which should not be done in construction. Despite, material procurement for mobilization commenced early 2011 actual procurement process for project work can be considered with effect from 2nd of April 2012. The data entered in ERP system is the real procurement details pertaining to Construction of DHQC project from 2nd of April 2012 to 31st of December 2012. The

data gathered even during that period also include office and furniture requirement procured for mobilization of project teams. Mobilization consists of preparatory work and operations necessary for the movement of personnel, equipment, supplies, and incidentals to the project site for establishment of offices, buildings, and other infrastructure facilities necessary for the work. This happened mainly due to insufficient time allocated for planning of project, which consider the most important stage of a project. The better the planning of a project lessen the risk faced by project team members.

This was a new location for military personnel consist of functional teams of PMU and CMU as well as architect and consultant. When the client decides to seek professional services for the design and construction of a facility, client needs to confront with a broad variety of choices. The type of services selected depends to a large degree on the type of construction and the experience of the owner in dealing with various professionals in the previous projects undertaken by the firms. This being the largest building project in magnitude of the footprint and project cost selection of architect and consultant is a complicated task. The client should have consulted expertise advice that had experience in similar magnitude of building project prior to implement the proposal. Focal point of client aimed at single direction, which was to retain expenses within the country while capacity building of military personnel to undertake larger project in future.

Cutting down the previously planned 54 months programme to 30 months put functional teams into serious difficult situation compelling them to absorb professional staff to DHQC project, which in turn would be a great impact to local construction industry. Finally, it can be assumed that average worth of work done per month will be over LKR 1.0 Billion that is a massive amount compared with historical capacity of Sri Lankan construction industry. Those factors affected the mobilization period of the project while constructions are underway. The researcher still feels that architect does not possess sufficient capacity and experience to advice inexperienced contractor formulated from tri-service personnel.

4.5 DATA FOR THE SELECTED CASE STUDY ANALYSIS

4.5.1 Current Situation

Major portion of PM and all procurements, which were initially done by Lanka Logistics and Technologies Pvt Ltd, subsequently handed over to PMU followed a manual operation. Engineers used very few functions of PM tools like Primavera and Micro Soft Project to monitor the progress but it did not help great extend keep track on the progress and material management. Productivity of the project principally depends on the efficiency of the Procurement of Goods and Services required. The mission of the research is to inspire and excite organizational leaders about emerging technology that makes workplaces more efficient.

One of the key factors in project success is successful management of procurement as it is the core activity of DHQC Project. It includes procurement planning, supplier selection, purchase order creation, invoice verification and payment management. Under this scenario ten commission officers from tri services, one accountant from Treasury assisted by forty non-commission officers constitute the procurement and finance directorate. As mentioned before, almost all the procurement processes are managed by manually necessitating focus on more staff to meet project objectives. Deficiency of present staff declared above compelled them overworking to overcome the challenge of accomplishing procurement objectives which has generated great physical and mental imbalance within the staff. Make use of advanced technology would be the most excellent answer to get away with the procurement delay affecting the productivity of the project as a whole.

Constructions are done by SLA, SLN and SLAF in three different zones to facilitate easy contract management. The specifications and number/quantity and delivery date of materials are determined by the respective Zone Managers with the consultation of CECB. Thereby individual construction teams/Zone Managers initiate a work order. which is the document that provides important details about goods and services that above groups want to obtain from procurement branch. A work orders are forwarded to main stores when a stock of supplies needs to be refilled or in other situations when the

construction team has a need for a certain good or service. Main stores running under an officer in charge of stores hold the responsibility of ensuring stock position with the help of fifteen military personnel deployed for the task and separate numbers are allocated for respective items in terms of category and nature of goods and services and forward it to PMU for approval to initiate procurement action. An officer assisted by five non-commission officers manages these documents at PMU and direct to procurement branch.

Procurement of goods is managed by three groups, each headed by an officer with the assistance of permanent group of non-commissioned officers. These groups each comprise of minimum ten members, involved in processing documents in terms of building material, hardware items and tools and machinery. Average number of files process per week is well below fifty. However, items progress in one file is varying with the cost of item and quantity depending on the situation and urgency. Following table shows the average time taken for procurement process starting from the initiation of work order.

4.5.2 Data Population of the ERP

The integrity of the data used to operate and make decisions about the project have an effect on the relative efficiency of operations and quality of decisions made. Protecting that integrity is difficult; it becomes more difficult when the size and complexity of the project, and its systems increase. No project will reap this benefit automatically at the initial stage of implementation. Sadagopan (1999, cited in Dixit, Ashish Kr; Prakash 2011) argued that though the cost of an ERP system implementation is very high, it provides significant benefit to enterprise in the long run. Literature review has explored/identified some factors affecting the implementation of ERP system. Enterprise can achieve this benefit through careful attention and up-front design work early in the project (Dixit & Prakash, 2011). Identification of barriers, collecting of required data and entering in to the system needed careful attention prior to implementation. Lack of trained staff who are familiar with the web based ERP system of M/S Sapere (Pvt) Ltd delayed data entering process.

The most critical success factors of ERP implementation has been identified as training of personnel to respective package. In order to realize significant benefits from ERP systems a considerable amount of training is required. For successful operation, training plan is one of the critical factor and it should take into consideration both technical staff and end-users, with its scope depending on the type of implementation approach selected. (Esteves, Pastor, & Casanovas, 2002). Training is important in an ERP implementation project not only to adapt users to the new ERP system but also to help in the organizational change process. Researcher observed it helped users to obtain knowledge of the ERP system before it is going live. Therefore, training of personnel was the first step taken for data entering and initiated to educate four non-commissioned officers about basic functions of ERP system.

Entering of data started on 1 March 2013 and it took almost one month to get them acquaintance with the system without disturbing other project works already entrusted. Poor knowledge and ability to use computers and related technology efficiently resulted extra training of personnel detailed for the assignment. With much effort, difficulties were managed to achieve positive outcome. The chronology of ERP data entering process can be summarized as follows.

Define Project

The construction project considered for case study is in the pace of main structural work, which excludes material for dry finish of construction process (wall/roof cladding work, internal partition/fixtures and other special architectural embellishments) and major Mechanical, Electrical, Plumbing and Information Communication Technology (MEPI).

With above details project was defined which include Number of bills, tendered date. Project award date, expected start date, completion date, contact for delivery, tax category etc.

Define Items

All inventory items were defined denoting project name, secondly item category, and thirdly first three letters of the items to overcome mixing up inventory items with already

available data fed to the ERP system of M/S Sapere (Pvt) Ltd and stock integration to the general ledger. Second inventory coding identification was the main identification code categorization divided into five groups as depicted below.

- I Building Material
- II Tools and Equipment
- III Office Equipment
- IV Plant and Machinery
- V Vehicles

All the potential units of measure appropriate to stock items was defined from the units of measure form under the Setup tab of the main menu under inventory setup of ERP system of M/S Sapere (Pvt) Ltd. Stock category is very significant as it help stock integration to the general ledger.

Entering Suppliers Data

Defining supplier's code is the most important task, as it will help search a supplier details with regard to purchases made, account inquiry, and items supplied to the respective project when ERP operates live. Therefore suppliers were defined taking first three letters of all suppliers as supplier code. Subsequently details of supplier address, telephone numbers, supplier type, payment terms and tax group were entered.

Entering of Material and Assets

Entering building materials is straightforward in procurement process. It is required only to select the supplier who won the bid and entered initial details of the order (delivery date and requisition reference), then warehouse information(warehouse number or type, delivery contacts, address) and finally suppliers information from which items/building materials going to purchase. However, in this research new items were defined first notation as DHQC as discussed previously purely to avoid mixing up of inventory items. The next step is to set up a price for newly entered item under "item price" and validity period of that price. When entering assets under fixed assets menu its code, type, location, depreciation rate, consuming units, fuel type become key factors to consider.

Raising a purchase order is process of initiating a purchasing process from a particular supplier. Raising purchase order is followed by defining the location where the items should be supplied to and selecting the stock items which have to be delivered (items can be searched from the drop down menu and added to the purchase order). After successfully entering the information shown in above order can be processed. The purchase order also can be printed after successfully processing.

GRN is a document produced when goods are received into the stores. It will usually accompany goods to any inspection and is used to check against invoices before payment. Creating an invoice is a process of paying a supplier for that particular service provided. The invoice value which is paid to the supplier will be value of the goods or assets.

Entering BOQ Items

Preparation of BOQ by the client/consultant organization prior to bid invitation is the first step to ensure project cost falls within the expected budget. BOQs prepared manually or using any other software available for PM can be directly entered in the ERP.

There are two options to add a BOQ item; one is adding BOQ item directly for which item cost can be derived without any additional mathematical calculations; second opportunity is for items combining two or more materials to create one BOQ item which is called BOQ with rate analysis. ERP has the facility to enter BOQ with rate analysis in two stages to make the process user friendly. Adding of BOQ item is very easy. First select the bill relevant to the BOQ item, item code, description, unit of measure, BOQ quantity and rate and enter relevant details.

Defining BOM for BOQ Item

Preparing of Bill of Material (BOM) is vital to the effective planning of any construction project. In this case study, once the entering of BOQ items to ERP System is completed, defining of BOM for each BOQ items can be done either by defining new items or using data already available in the system. System provide three alternatives to enter BOQ rate analysis; add BOQ item and then perform rate analysis later under the command "BOQ

item rate analysis"; in a single operation under the command "add BOQ item with rate analysis" and last option is adding BOQ item with rate analysis from existing project.

Verify Initial Budget of the Project

On completion of entering BOM and BOQ, under "view project budget" system automatically calculate project budget and provides facility to compare BOQ rates against budgeted cost of relevant item. This is a very good tool facilitated in the system and will be an early warning to the contractors to decide in which BOQ item he is going to lose or win. To researcher's knowledge, no such facility is available in any software or any PM tools used in Sri Lankan construction industry.

Work Orders

Work orders are the cornerstone in construction planning in the ERP system. Work Orders enable component allocation, routing, and Material Requirement Planning (MRP) features. In construction, the definition of a work order should be parallel to a work break down structure element of the project plan.

To initiate a work order define the start date of the work and the planned finish date. Add a description and define the interim bill for the work order. Most importantly define the work breakdown structure element related to the work order. Each work order requires particular amounts of resources to be completed. Issuing Resources to selected work order can be performed in the system. Final step is to process the work order. Processing a work order means the acceptance of completion of work done for a particular work order. On completion of above segment of entering data, system provide graphical representation of percentage of work completed of each work order giving clear picture of overall project progress.

Petty Cash Account

Petty cash is held in order to make immediate payment of small expenditure items, which cannot be met through normal government procurement procedure. This may include Travel (short taxi journeys), Postage, Minor refreshments (coffee/tea for external

visitors), Small consumables (ad hoc stationery) and sometimes-urgent construction material.

Project Monitoring

Regularly monitoring of the project's schedule performance can provide early indications of possible activity-coordination problems, resource conflicts, and possible cost overruns. In the ERP system of M/S Sapere (Pvt) Ltd. project monitoring means monitoring the work in progress which is based on the work orders and compare with the Gantt chart prepared in PM tools such as MS Project or Primavera. Work in progress therefore refers to all materials and partly finished work that are at various stages of the construction process. The system has the flexibility to get overall project view in respect of planned and used quantity and cost of work orders, usage variance and cost variance. In addition, it has provided the facility to view project total resource requirement, monthly or weekly project resource plan, graphical representation of project cost distribution, monthly or weekly resource demand, resource usage, and stock availability. In a project, the most important parameter of PM is Earn Value Management (EVM) parameters. EVM is a technique that allows to determine more precisely, where project stands in terms of baseline schedule and budget. ERP system of M/S Sapere (Pvt) Ltd. calculates some parameter derived from EVM such as Cost Performance Index (CPI) and Schedule Performance Index (SPI).

4.5.3 Evaluation of Quantitative Data in ERP System and Manual Operation

Adequate set of data should be available to analyze the positive and negative attributes of utilization of ERP systems. Therefore following set of information are examined in favour of and against ERP implementation. The process commenced from selection of suppliers up to completion of particular construction segment. In order to gain better understanding of main subject area of qualitative data analysis, which seems complex to analyze as a whole is partitioned in to following subcategories.

- I. Analysis of time - Analysis based on time taken to process an activity prior and after implementation of ERP
- II. Project Data Availability to Project Team Members

Analysis of Time

Technological advancement and innovation are the long-term boosters of economic development. For a developing country like Sri Lanka, it is important to lay a strong foundation for building its capacity to acquire and create knowledge in order to take opportunities offered by globalization. During the past, all governments attempted to improve computer literacy among Sri Lankans through various policies and programmes. Yet, expected results have not been very encouraging (Silva, Kodikara, & Somarathne, 2013).

Unlike other developed countries, Sri Lankan construction industry and Government sectors are far behind using ERP systems. In this context, manual methods take lead role in procurement processes of manufacturing, construction, development and sales disciplines. In this case-study, Bid preparation, invitation, closing, appointing TEC, and Bid evaluation that basically identified as procurement processes from Bid invitation to evaluation did not take into consideration.

Guide to Project Management Body of Knowledge (PMBOK) defines 5 process groups, 10 knowledge areas and 47 processes while ISO 21500 describes 5 process groups, 10 subject groups and 39 processes (Labriet, 2012). However moving away from theoretical framework and focusing practical scenario related activities of project site and ERP, it is considered mainly six subject groups; Asset Management, Cost Management, Time Management, Project Forecast, Account and Financial Management and Procurement and Stores Management. Out of more than 200 functions in the ERP System, only the data set, which has major impact on the project, is captured under selected set of processes / areas.

The management of organization considered for this research operates in three different hierarchical levels. The three levels of management typically found in an organization are low-level management, middle-level management, and top-level management. The three levels of management of the case study under consideration are MOD, PMU, CMU and staff. Director and Project Managers of PMU and Director and Deputy Directors of CMU constitute Managerial Level and supporting staff of those divisions constitute Operational

Level. MOD will act as top-level management responsible for controlling and overseeing the entire organization.

Analysis of time taken for each activity under six subject groups is a new challenge. Author intends to carryout longitudinal time analysis to get more accurate outcome. Information garnered during random visit to respective directorates, observation made in year 2013 at DHQC project and entering data to ERP system by four trained personnel utilize to measure time taken for each activity. However, there are instances that duration of activities cannot be measured merely by observation. In such occasions, outcome of focus group discussions with Managerial Level Staff uses for verification of periods, which are not measurable at site. Process of finding a logical way to calculate time consumption of which information are not available in manual system is more challenging. Expertize knowledge also uses to frame and arrange unavailable information to validate data set which are tabulated in Appendix A.

The benefits achieved by Managerial Level and Operational Level are identified separately by comparison of two scenarios. This is one of the best solution researcher perceived to convert these raw data into meaningful information. Accurate judgment of frequency of occurrences of activities under six subject groups of previously mentioned Management and Operational Level is of vital important to develop better research outcome. Results of focus group discussions with managerial personnel time to time with regard to frequency of occurrences of activities utilize for comparison. Author aims at focus group discussion to evaluate reasonable time for unavailable data of existing system and compare with the time consumed after implementation of ERP System. This is tabulated in Appendix B.

In order to communicate above data visually, this information is plotted in a vertical bar chart to show comparisons among processes groups.

Time Reduction on Asset Management

Asset Management takes a lead role in managing a project in an efficient and effective way. The main aim of Asset Management is to assist agencies in managing assets cost effectively. Project needs a good Asset Management to develop operational performance

and profitability of industry. Effective management of asset is a major determinant of organizational success.

Table 4.1: Time Reduction on Asset Management

Process	Percentage of Time Reduction	Percentage of Time Reduction Weighted in Frequency of Occurrences of Managerial Level	Percentage of Time Reduction Weighted in Frequency of Occurrences of Operational Level
Viewing All Assets Registry	82.2%	15.5%	7.6%
Finding Assets Location	82.9%	25.5%	37.6%
Work Center Details	88.9%	17.7%	14.5%
Asset Maintenance Cost	97.9%	29.8%	28.5%

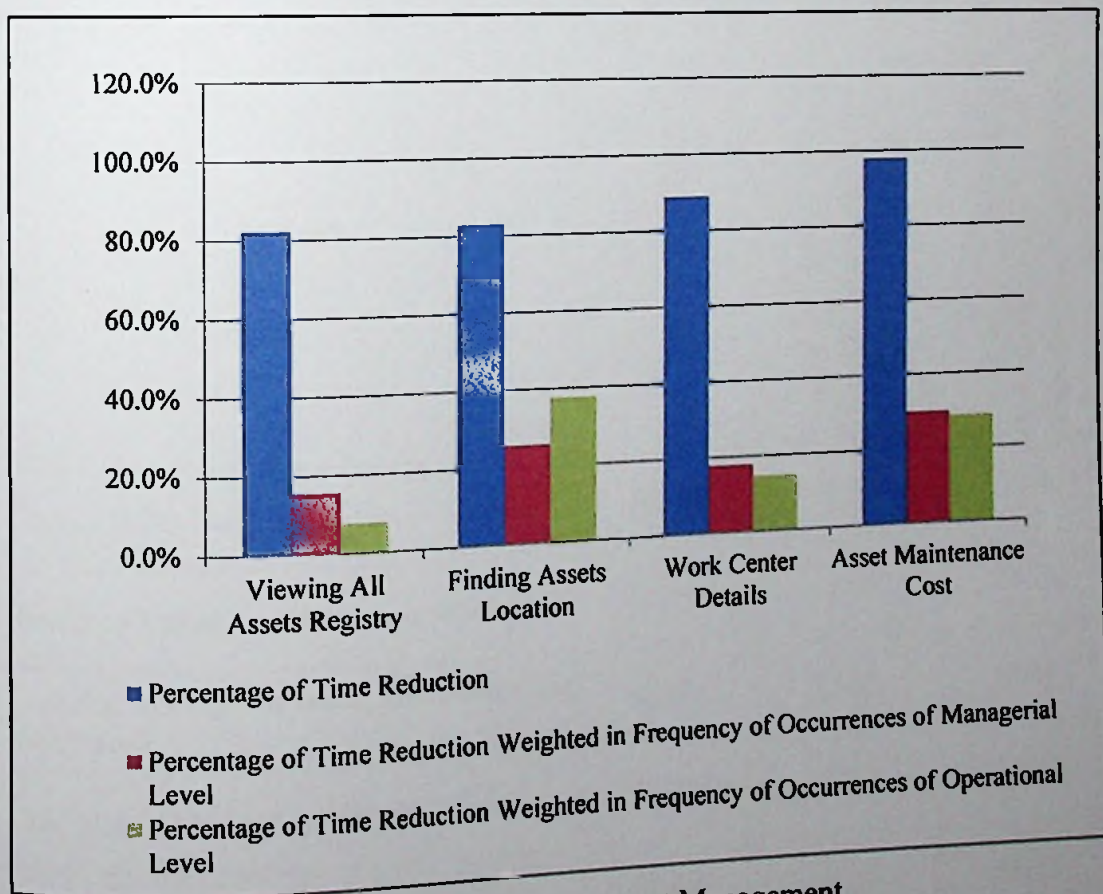


Figure 4.2: Time Reduction on Asset Management

Time reduction of each process categorizes under Asset Management after implementation of ERP system is above 82% that is a massive advantage to elevate the productivity of a project. After deployment of ERP, case study proves that time saving in Asset Management at Managerial and Operational Level based on data shown in Appendix A is 88.5% and 88.2% respectively. In other words, staff of Managerial Level reaps more benefit than Operational Level.

Time Reduction on Cost Management

Cost Management has a much broader focus and it is a way of measuring cost and productivity throughout the life cycle of projects. However, author here considers only the activities in ERP system that relates to Cost Management.

Table 4.2: Time Reduction on Cost Management

Process	Percentage of Time Reduction	Percentage of Time Reduction Weighted in Frequency of Occurrences of Managerial Level	Percentage of Time Reduction Weighted in Frequency of Occurrences of Operational Level
Cost of BOQ Items	92.0%	12.3%	21.0%
Resource Variation Cost due to Wastages	94.7%	12.6%	22.6%
Cost due to Price Variation (Purchases Vs Estimated)	95.0%	15.7%	10.6%
Cost of BOQ Items Completed	95.0%	27.6%	20.4%
Cost Performance Index (CPI)	97.5%	9.5%	9.0%
Project Income from BOQ Items	95.0%	17.1%	10.8%

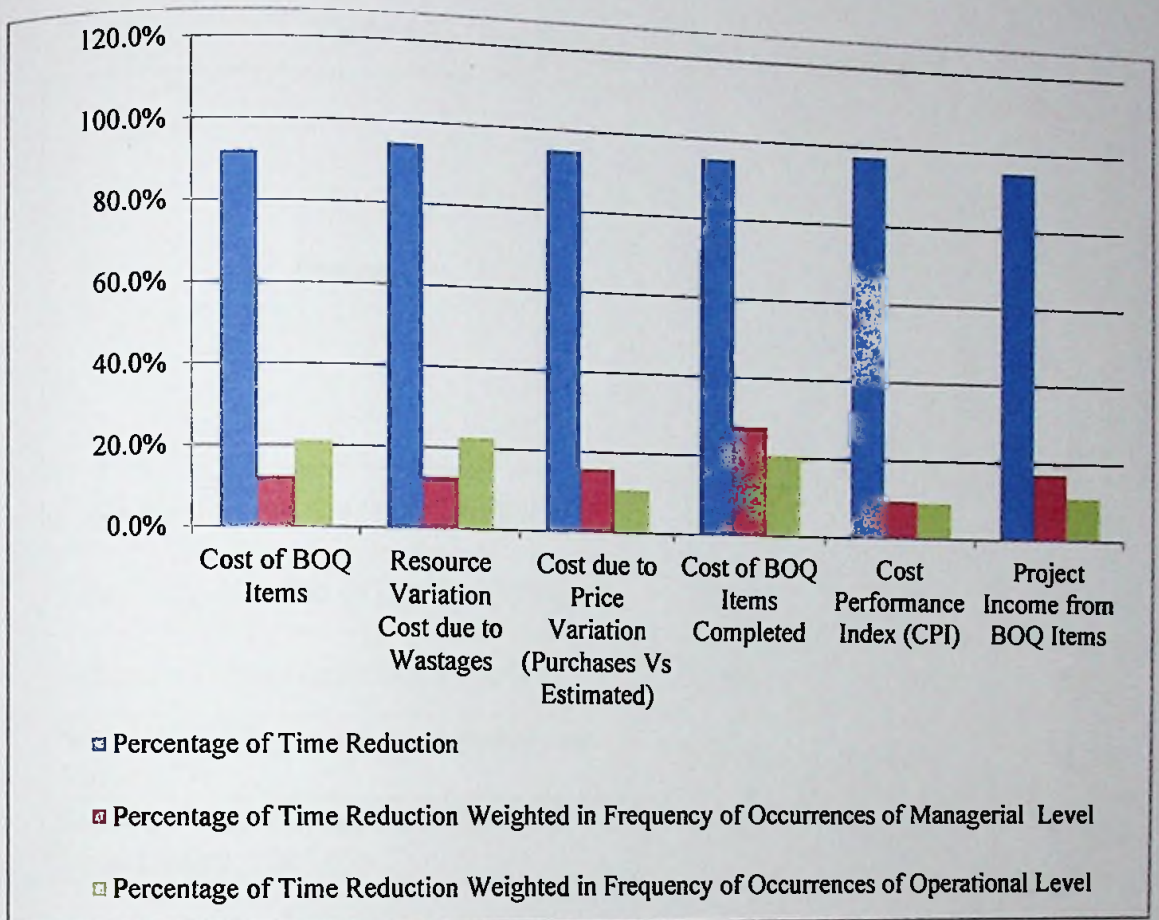


Figure 4.3: Time Reduction on Cost Management

Time reduction of each process categorized under Cost Management after implementation of ERP system is above 92%. Percentages of time reduction of Cost Management in Managerial and Operational Level based on data shown in Appendix A are 94.8% and 94.5% respectively. Here also staff of Managerial Level reaps more benefit than Operational Level.

CPI value is a very powerful tool defined in EVM. Since CPI is an index, showing efficiency of utilization of resources it helps project team members to track and ascertain whether project is over budget or under budget. Time reduction of CPI is 95% and getting this value from ERP needs minimal effort.

Time Reduction on Time management

Effective PM requires adequate time for planning and implementation of these plans. Here author consider only activities relates to schedule performance, which are defined in ERP system.

Table 4.3: Time Reduction on Time Management

Process	Percentage of Time Reduction	Percentage of Time Reduction Weighted in Frequency of Occurrences of Managerial Level	Percentage of Time Reduction Weighted in Frequency of Occurrences of Operational Level
Total Budget Value as per Schedule	85.0%	16.5%	16.9%
Total Budget Value of Completed Items	88.0%	23.5%	41.3%
Schedule Performance Index (SPI)	97.9%	31.4%	8.8%
Schedule Performance measurement on Value of Work	95.8%	10.5%	11.5%
Schedule Performance on Time as per Total Duration in Days	95.8%	10.5%	11.5%

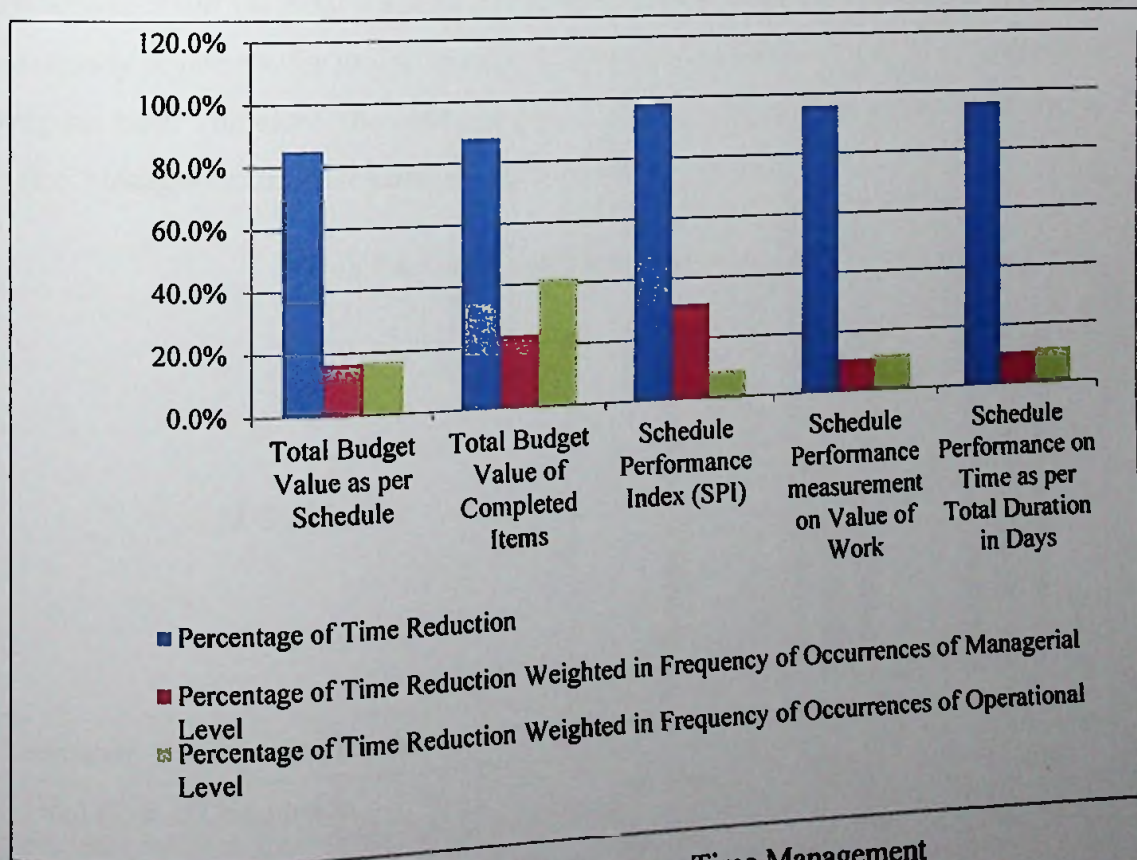


Figure 4.4: Time Reduction on Time Management

Time reduction of each process categorized under Time Management after implementation of ERP system is above 85%. Percentages of time reduction on time management in Managerial and Operational Level based on data shown in Appendix A are 92.3 % and 90.2% respectively. Here also staff of Managerial Level earns more benefit than Operational Level.

SPI values, which are defined in EVM concepts, are readily available in ERP system. Since SPI is an index, showing how the work is progressing compared to the original schedule. Providing accessibility and availability of these indices are of huge advantage for managers to track and evaluate the project. These data can be shared quickly and easily between departments facilitating others to update project progress. Accordingly, redundant data entry can be eliminated.

Time Reduction on Project Forecast

Organizing, planning and controlling are highly critical components of PM. Reliable predictions about the final duration and cost of projects starting from project inception are equally important for project manager to ensure completion of project as schedule at budgeted cost. Therefore, the effectiveness of project controls relies on the capability of project managers to make reliable forecasts in a timely manner.

Table 4.4: Time Reduction on Project Forecast

Process	Percentage of Time Reduction	Percentage of Time Reduction Weighted in Frequency of Occurrences of Managerial Level	Percentage of Time Reduction Weighted in Frequency of Occurrences of Operational Level
Estimated Cost at Completion	94.4%	25.1%	18.9%
Actual Cost at Completion	96.7%	42.6%	51.6%
Cost Saving/Cost Overrun	94.5%	27.8%	25.2%

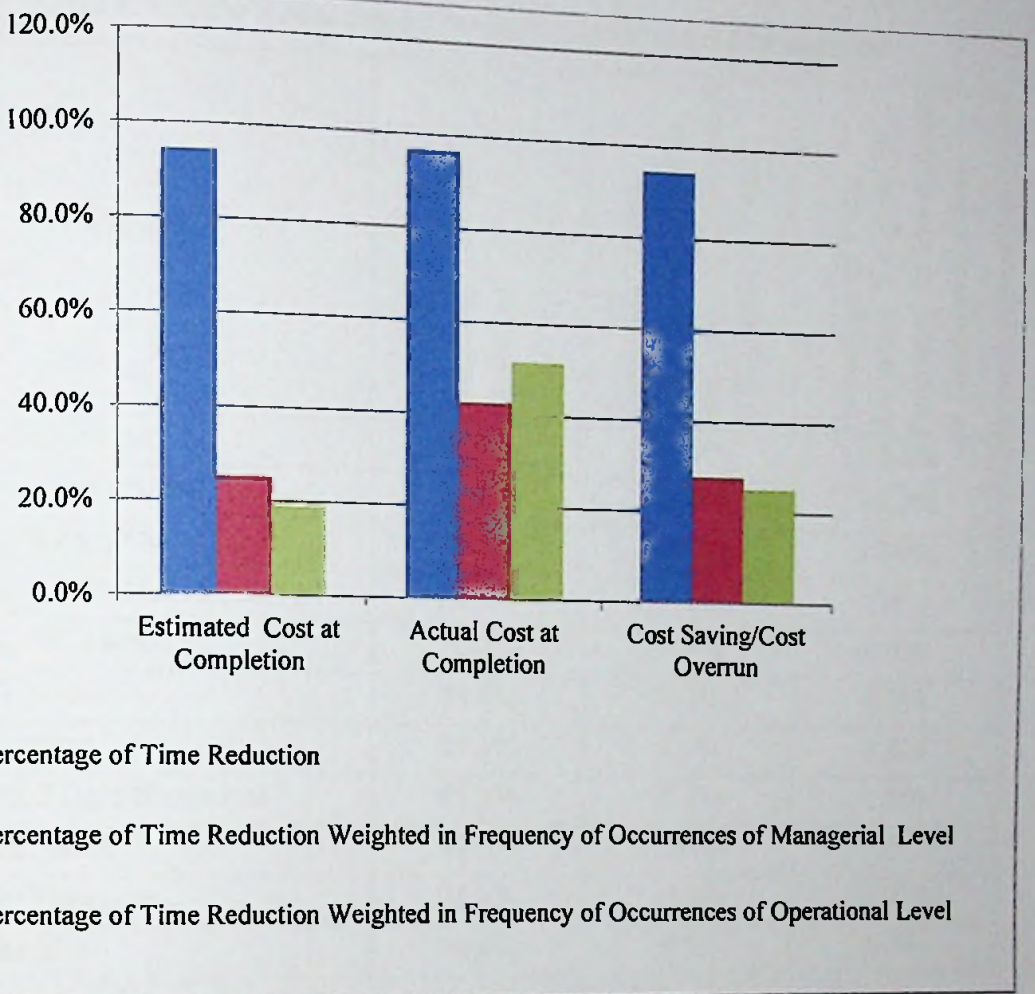


Figure 4.5: Time Reduction on Project Forecast

Time reduction of each process categorized under Project Forecast after implementation of ERP system is more than 94%. Percentages of time reduction of Project Forecast in Managerial and Operational Level are 95.5% and 95.7% based on data shown in Appendix A respectively. Here in contrary staff of Operational Level reaps more benefit than Managerial Level.

Time Reduction on Project Account and Financial Management

Business finance is that business activity which concerns with the acquisition and exchange of capital funds in meeting financial needs and overall objectives of a business enterprise. The term Account and Financial Management encompasses activities which includes recording, classifying, and summarizing financial transactions. (Paramasivan & Subramanian, 1995).

Table 4.5: Time Reduction on Account and Financial Management

Process	Percentage of Time Reduction	Percentage of Time Reduction Weighted in Frequency of Occurrences of Managerial Level	Percentage of Time Reduction Weighted in Frequency of Occurrences of Operational Level
Petty Cash Report	86.7%	10.5%	12.6%
Accounts Receivable	87.5%	10.6%	16.7%
Accounts Payable	88.9%	10.4%	12.9%
Supplier's account inquiry	84.4%	7.1%	5.4%
Item Stock Value	76.0%	7.1%	6.9%
Sales Values	84.4%	9.3%	6.1%
Depreciation	87.3%	3.5%	4.8%
Profit and Loss Statement	85.0%	1.5%	1.5%
Balance Sheet	90.0%	1.6%	1.6%
Indirect Expenses	91.7%	15.4%	10.0%
Overheads	90.0%	9.8%	8.2%

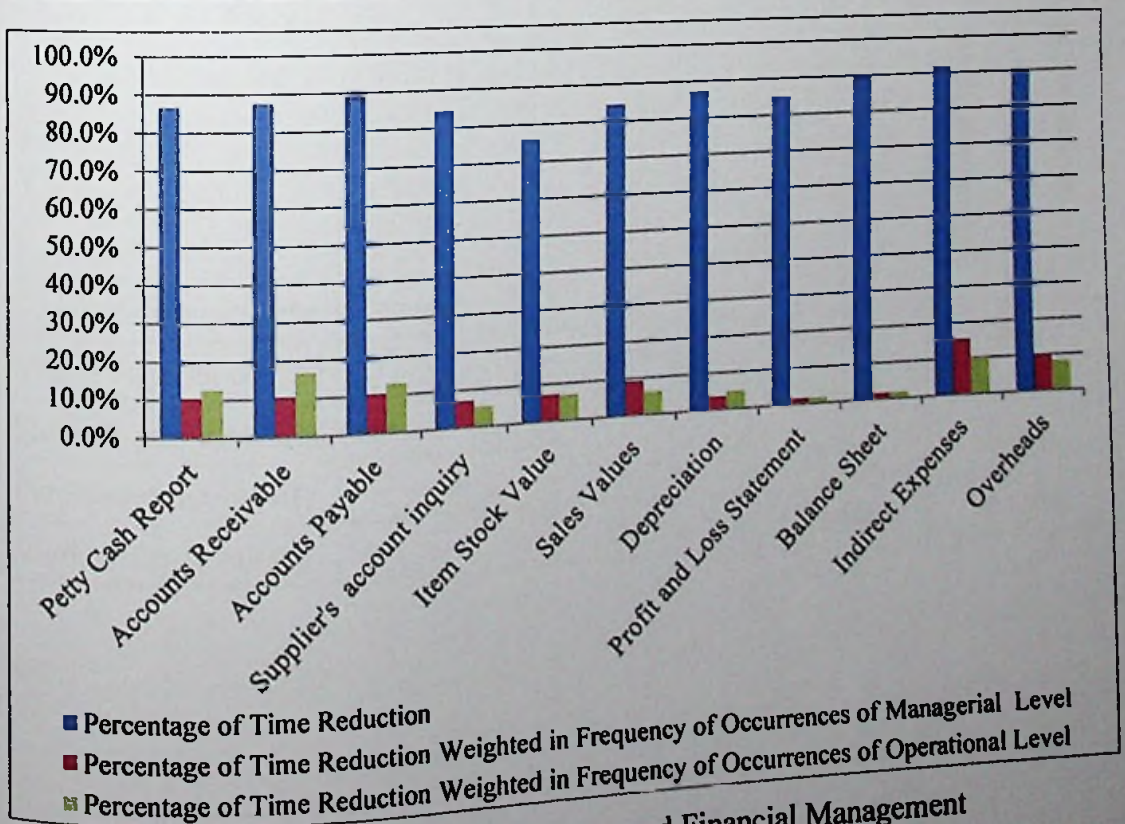


Figure 4.6: Time Reduction on Account and Financial Management

Time saving of activities of Account and Financial Management varies between 76% and 91.7%. Percentages of time reduction of Account and Financial Management in Managerial and Operational Level based on data shown in Appendix A are 86.9% and 86.8% respectively. Here the difference is marginal but these percentages express that more benefits acquire by managers than operational staff.

Time Reduction on Purchase and Stores Management

Purchase and stores management are a vital part of construction industry concerns. It has, therefore, to be tailored to suit the particular needs of the organization. The author considers only the most important processes defined in ERP system as shown below.

Table 4.6: Time Reduction on Purchase and Stores Management

Process	Percentage of Time Reduction	Percentage of Time Reduction Weighted in Frequency of Occurrences of Managerial Level	Percentage of Time Reduction Weighted in Frequency of Occurrences of Operational Level
Supplier's contact details/Category	85.0%	19.0%	16.1%
Search material or item	80.0%	12.7%	24.8%
Stock status of material/item	91.1%	17.1%	16.4%
Purchase order inquiry	80.0%	15.7%	12.2%
Work Order Inquiry	82.9%	19.4%	13.9%

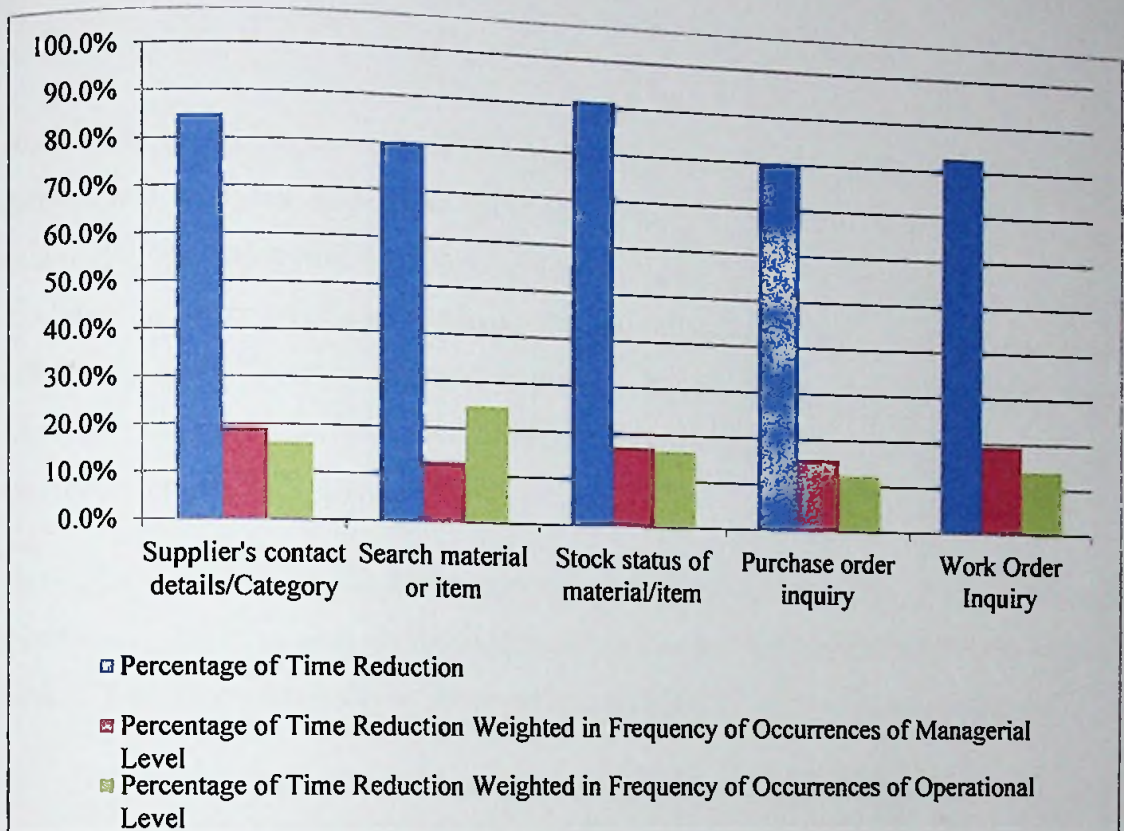


Figure 4.7: Time Reduction on Purchase and Stores Management

Time reduction of each process categorized under Purchase and Stores Management after implementation of ERP system is above 80%. Percentages of time reduction of Purchase and Stores Management in Managerial and Operational Staff based on data shown in Appendix A are 83.9% and 83.4% respectively. Here also Managers get more benefit than Operational Level staff. This helps to cut down human resources and speed up PM and procurement processes. Thus, project will gain a huge financial benefit

Project Data Availability to Project Team Members

Data availability is often of extreme importance to PM. The case study of this research reveals that data are not available and not accessible to all team members. Available data spread across multiple departments restricting accessibility. For the assessment of benefits gained by implementation of ERP system, team members of project under study are categorized into two clusters as mentioned in previous instance; Managerial and Operational Level. Managerial Level constitute of managers of all disciplines, directors and deputy directors of CMU and PMU while Operational Level constitute of all supporting staff of Managerial Level. In order to create clarity for the analysis of data

availability to project team members prior and after implementation of ERP. Author gathers and analyzes data under three scenarios. First situation is to determine data availability to Managerial and Operational Level prior to deployment of ERP, second is minimum requirement of data to Managerial and Operational Level to manage the project effectively and efficiently and third is data availability to Managerial and Operational Level after implementation of ERP. However, it is not a straightforward process and need careful attention to get reliable data set.

Having had discussions with Managerial Level personnel and analyzing the pros and cons those data present in five platforms depending on need and availability of information ranked in an ascending order as shown below. It further demonstrates in Appendix C.

Table 4.7: Ranked Order of Information Availability

Stages/ Platforms	Need and Availability of Information	Percentages Allocated
1	Null	0%
2	Low	25%
3	Medium	50%
4	High	75%
5	Full	100%

However, all above factors are dependence of frequency of occurrences or repeatability of individual events of project team members. Quantifying repeatability of these individual tasks are the next challenge encountered to shape up data set for analysis. Four, five focus group discussions held at different periods helped finalize the matter and summary of the results are shown in Appendix B.

Asset Management - Managerial Level

Information deficiency and gain derived from availability and minimum requirement of information to project team members are tabulated in Table 4.8 and graphically represents in Figure 4.8 as shown below.

Table 4.8: Asset Management - Managerial Level

Process	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Viewing All Assets Registry	16.7%	68.8%	83.3%	14.6%
Finding Assets Location	16.7%	70.8%	83.3%	12.5%
Work Center Details	5.6%	61.1%	94.4%	33.3%
Asset Maintenance Cost	0.0%	66.7%	100.0%	33.3%

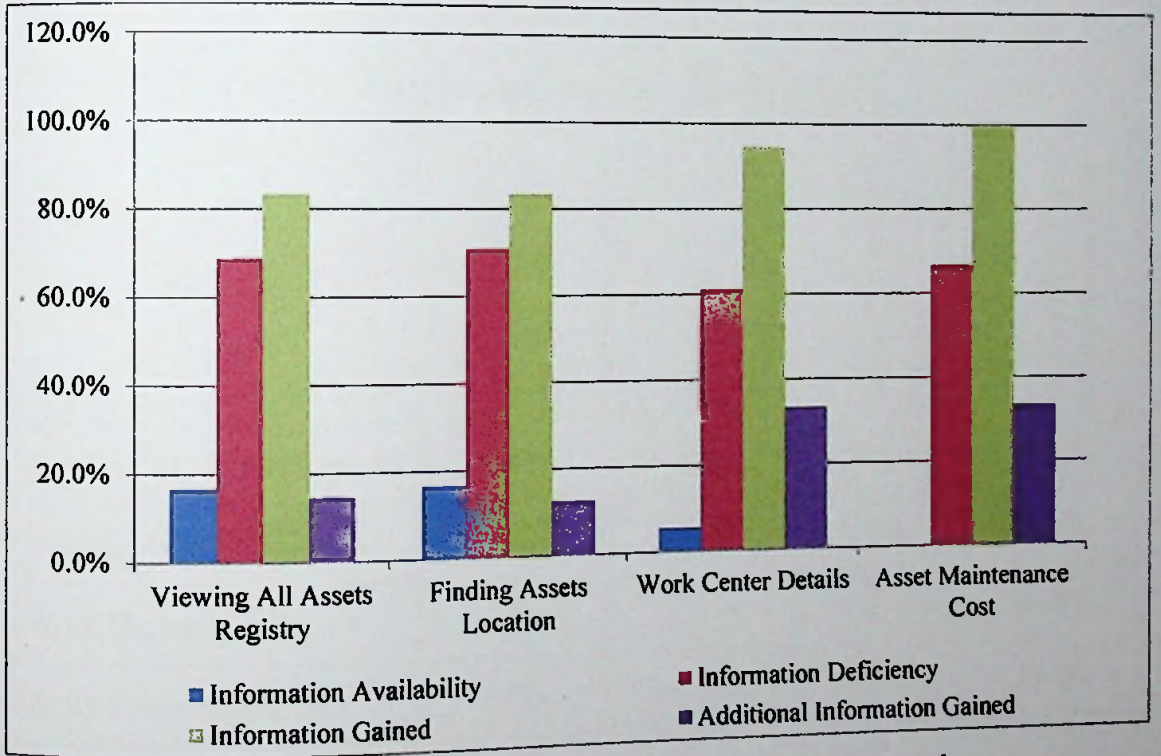


Figure 4.8: Asset Management - Managerial Level

This project owns heavy machineries, large vehicle fleet and construction plants but operation and maintenance cost of those are not available. Therefore, information availability under Asset Maintenance cost has become zero. Information deficiency varies from 61.1% to 70.8% while information gained after implementation of ERP system is higher than 83.3% including the additional information gained.

The information deficiency and information gained in the area of Asset Management in Managerial Level based on data shown in Appendix B are 67.2% and 90.6% respectively.

Asset Management - Operation Staff Level

The asset registry is available only with Project Manager Administration. Present system lacks appropriate mechanism for other team members to access up to date asset registry causing needless delays in project progress. Table 4.9 illustrates information availability and deficiency in terms of activities under Asset Management while Figure 4.9 graphically presents the comparison.

Table 4.9: Asset Management - Operation Staff Level

Process	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Viewing All Assets Registry	12.5%	46.9%	87.5%	40.6%
Finding Assets Location	12.5%	46.9%	87.5%	40.6%
Work Center Details	7.1%	32.1%	92.9%	60.7%
Asset Maintenance Cost	0.0%	36.1%	100.0%	63.9%

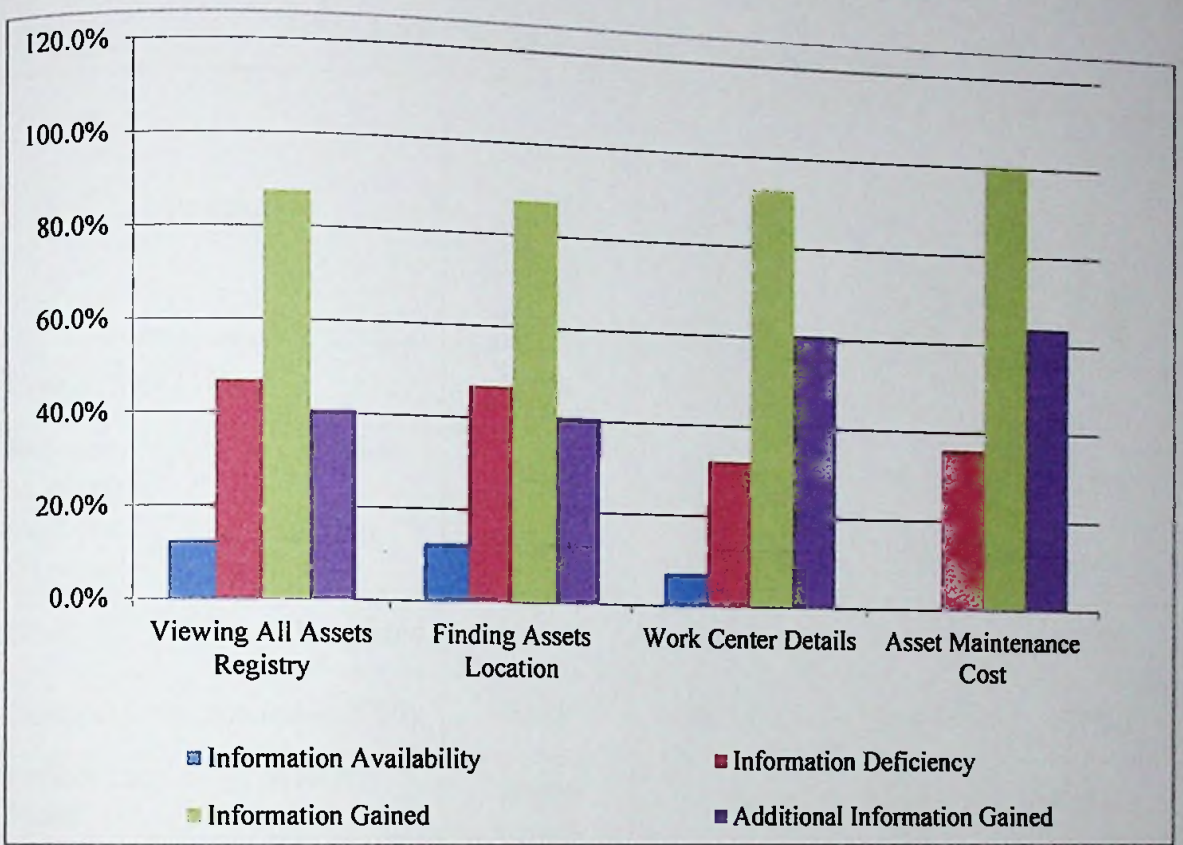


Figure 4.9: Asset Management - Operation Staff Level

Information deficiency varies from 32.1% to 46.9% and information gained after implementation of ERP system is higher than 87.5% including the additional information gained. Asset maintenance cost was not available even with the Project Manager Administration. Hence, information gained reached up to maximum level of 100%.

The information deficiency and information gained in the area of Asset Management based on data shown in Appendix B are 41.3% and 92% respectively.

Cost Management - Managerial Level

Information deficiency and gain derived from availability and minimum requirement of information to project team members under Cost Management are tabulated in Table 4.10 and graphically represent in Figure 4.10 as shown below. Cost of project is a vital factor and one of the triple constraints identified in PM. Planning and controlling the cost during the life cycle of project help achieve project objectives.

Table 4.10: Cost Management - Managerial Level

Process	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Cost of BOQ Items	41.7%	27.1%	58.3%	31.3%
Resource Variation Cost due to Wastages	0.0%	60.4%	100.0%	39.6%
Cost due to Price Variation (Purchases Vs Estimated)	0.0%	75.0%	100.0%	25.0%
Cost of BOQ Items Completed	16.7%	50.0%	83.3%	33.3%
Cost Performance Index (CPI)	0.0%	92.5%	100.0%	7.5%
Project Income from BOQ Items	18.8%	43.8%	81.3%	37.5%

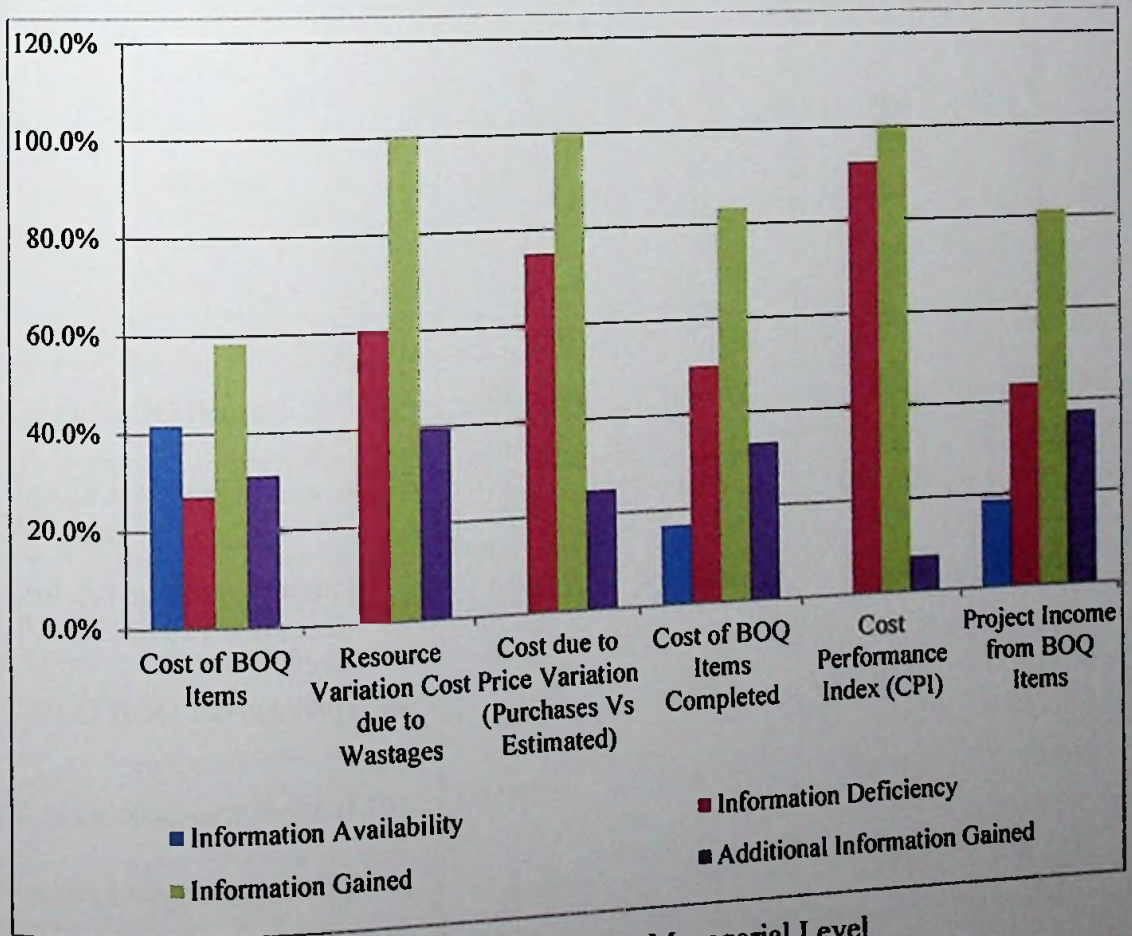


Figure 4.10: Cost Management - Managerial Level

Information deficiency varies from 27.1% to 92.5% while information gained after implementation of ERP system varies from 58.3% to 100% including the additional information gained. Resource variation cost due to wastages, cost due to price variation and CPI were not available at all. Hence, information gained reached up to maximum level of 100%.

The information deficiency and information gained in the area of Cost Management at Managerial Level based on data shown in Appendix B are 55.5% and 86.2% respectively.

Cost Management – Operation Staff Level

Table 4.11 illustrates information availability and deficiency in terms of activities under Cost Management while Figure 4.11 graphically presents the comparison.

Table 4.11: Cost Management – Operational Level

Process	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Cost of BOQ Items	30.0%	17.5%	70.0%	52.5%
Resource Variation Cost due to Wastages	0.0%	50.0%	100.0%	50.0%
Cost due to Price Variation (Purchases Vs Estimated)	0.0%	37.5%	100.0%	62.5%
Cost of BOQ Items Completed	20.0%	25.0%	80.0%	55.0%
Cost Performance Index (CPI)	0.0%	25.0%	100.0%	75.0%
Project Income from BOQ Items	15.0%	17.5%	85.0%	67.5%

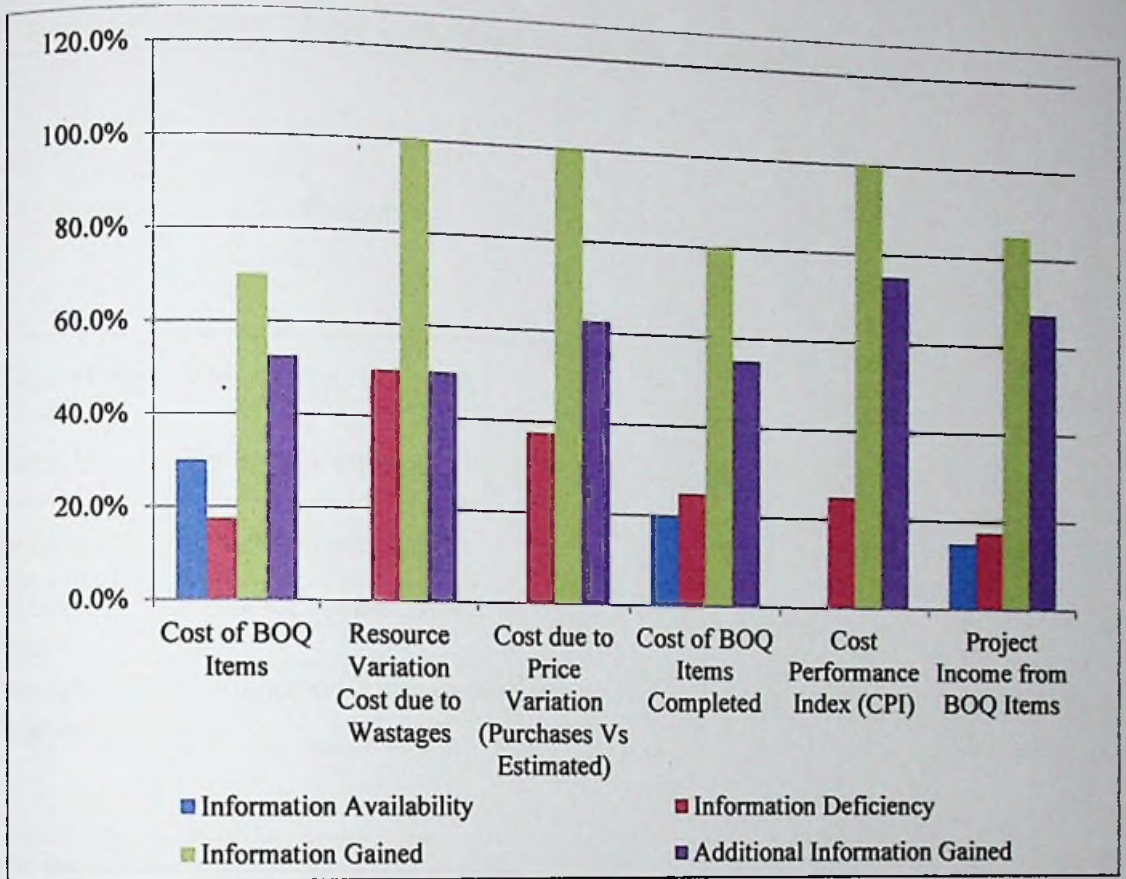


Figure 4.11: Cost Management – Operation Staff Level

Information deficiency varies from 17.5% to 50% while information gained after implementation of ERP system varies from 70% to 100% including the additional information gained. Resource variation cost due wastages, cost due to price variation and CPI were not available at all. Hence, information gained reached up to maximum level of 100%.

The information deficiency and information gained based on data shown in Appendix B in the area of Cost Management at Operational Level are 29.8% and 87.1% respectively.

Time Management - Managerial Level

Every Project Manager's aim is to ensure timely completion of the project. Bad management of project finally ends up with cost and time overrun. Tracking performance from the beginning of project and achieving set milestones throughout the life cycle help complete the project in a timely manner. Table 4.12 illustrates information availability, deficiency and gained while figure 4.12 graphically presents comparison.

Table 4.12: Time Management - Managerial Level

Process	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Total Budget Value as per Schedule	16.7%	43.8%	83.3%	39.6%
Total Budget Value of Completed Items	8.3%	58.3%	91.7%	33.3%
Schedule Performance Index (SPI)	0.0%	95.0%	100.0%	5.0%
Schedule Performance measurement on Value of Work	0.0%	57.5%	100.0%	42.5%
Schedule Performance on Time as per Total Duration in Days	0.0%	47.5%	100.0%	52.5%

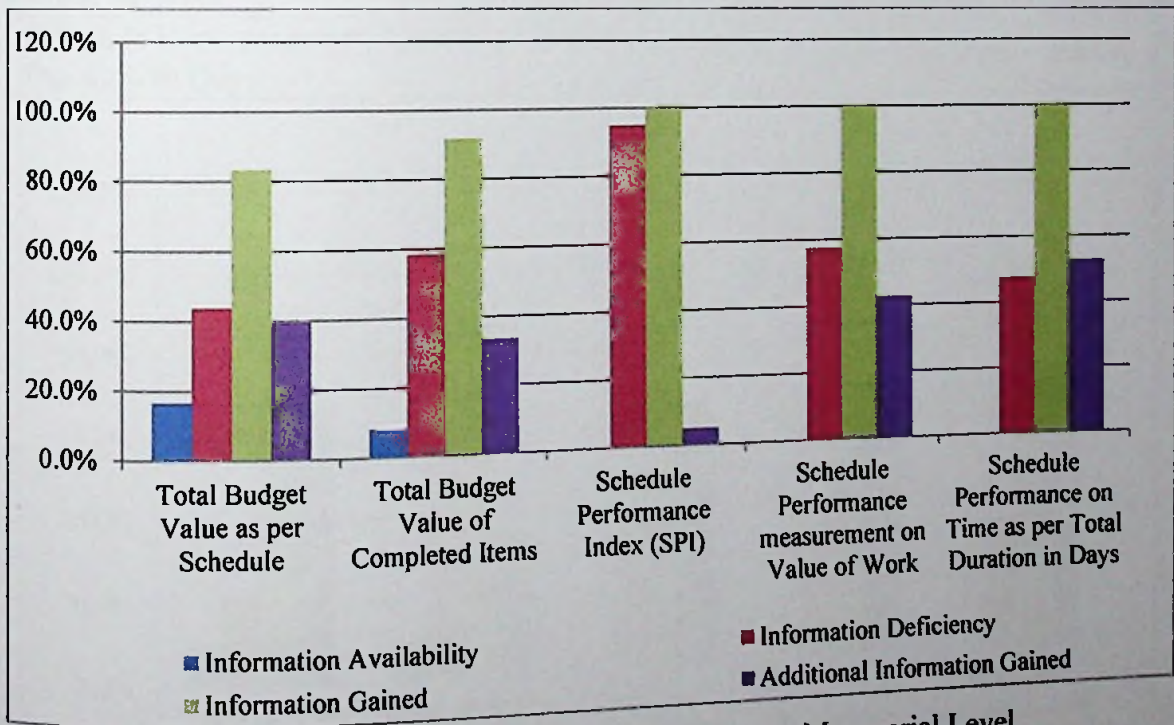


Figure 4.12: Time Management - Managerial Level

Information deficiency varies from 43.8% to 95%. Unavailability of schedule performance measurements and CPI value results information gained rise up to the maximum level of 100%. The information deficiency and gained are 66% and 94.5% respectively.

Time Management – Operational Level

Table 4.13 illustrates information availability and deficiency in terms of activities under Time Management while Figure 4.13 graphically presents the comparison.

Table 4.13: Time Management – Operation Level Staff

Process	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Total Budget Value as per Schedule	10.0%	22.5%	90.0%	67.5%
Total Budget Value of Completed Items	10.0%	55.0%	90.0%	35.0%
Schedule Performance Index (SPI)	0.0%	34.4%	100.0%	65.6%
Schedule Performance measurement on Value of Work	0.0%	33.3%	100.0%	66.7%
Schedule Performance on Time as per Total Duration in Days	0.0%	33.3%	100.0%	66.7%

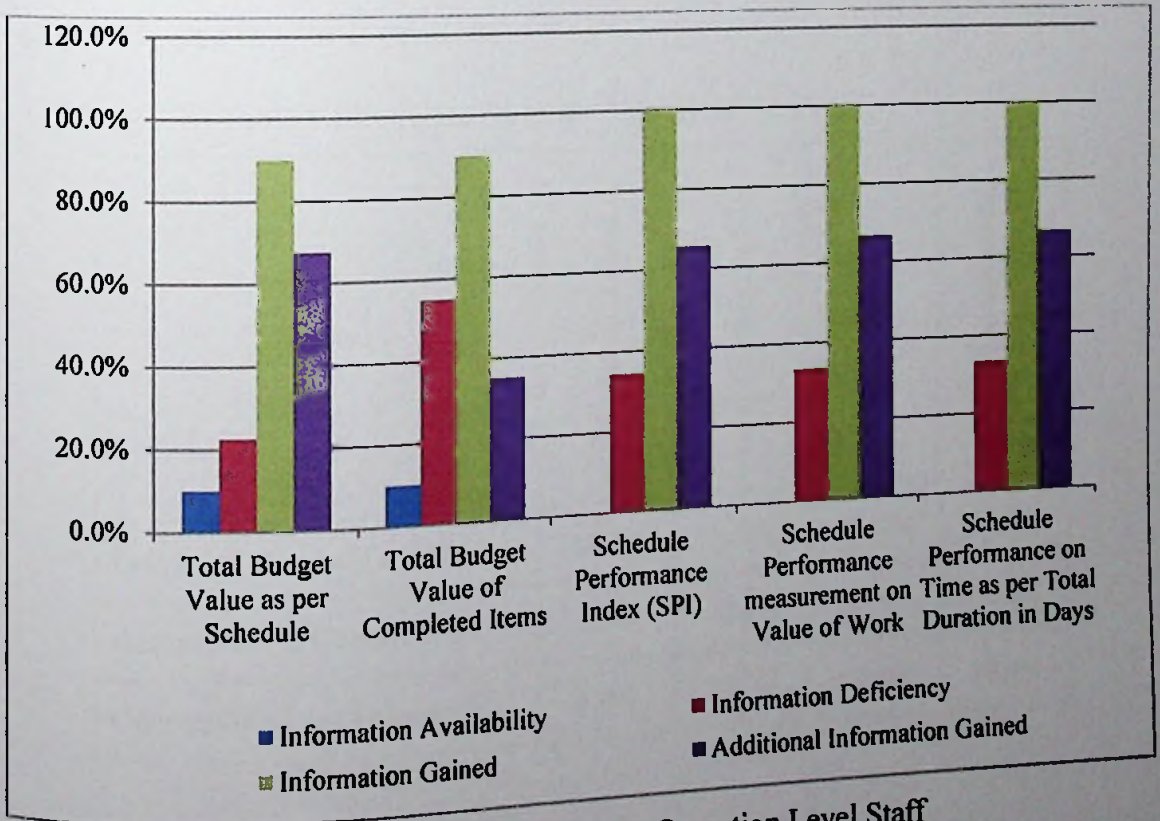


Figure 4.13: Time Management - Operation Level Staff

Information deficiency varies from 22.5% to 55% while information gained after implementation of ERP system varies from 90% to 100% including the additional information gained. The information deficiency and information gained based on data shown in Appendix B in the area of Time Management at Operational Level are 41.5% and 93.3% respectively.

Project Forecast - Managerial Level

A forecast is a statement about how the future will turn out based on evidence or assumptions. project forecasts often involve the analysis of data, such as the performance history of a particular project. The purpose of forecasting is to give managers insight into how profitable projects are likely to be in the future. Forecasting project is an extremely important element of the initiation stages of PM. During the initiation and planning stages, project managers will often complete "Forecasting" exercises to determine the project's scope, possible constraints, and potential risks. Table 4.14 illustrates information availability and deficiency in terms of activities under Project Forecast while Figure 4.14 graphically presents the comparison.

Table 4.14: Project Forecast - Managerial Level

Process	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Estimated Cost at Completion	16.7%	52.1%	83.3%	31.3%
Actual Cost at Completion	0.0%	68.8%	100.0%	31.3%
Cost Saving/Cost Overrun	0.0%	79.2%	100.0%	20.8%

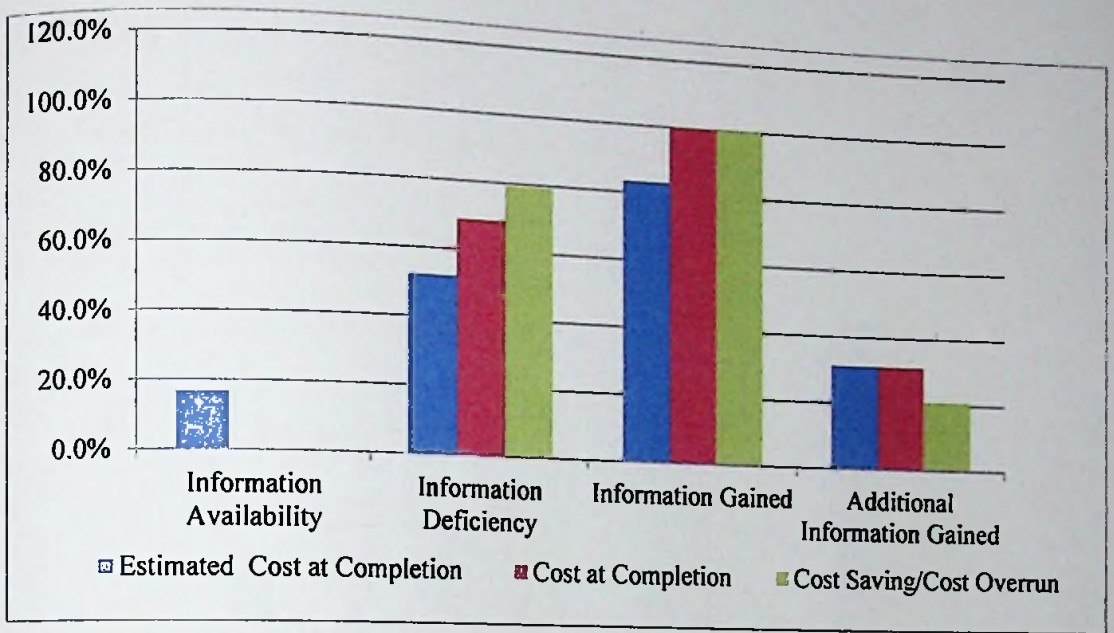


Figure 4.14: Project Forecast - Managerial Level

Here out of three activities defined in the ERP system that have major impact on project forecast estimated cost at completion is available with project team members. Information deficiency and gain varies from 52.1% to 79.2% and 83.3% to 100%.

The information deficiency and information gained based on data shown in Appendix B in the area of Project Forecast at Managerial Level are 67.4% and 95.6% respectively.

Project Forecast – Operational Level

Table 4.15 illustrates information availability and deficiency in terms of activities under Project Forecast while Figure 4.15 graphically presents the comparison.

Table 4.15: Project Forecast - Operation Staff Level

Process	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Estimated Cost at Completion	10.0%	22.5%	90.0%	67.5%
Actual Cost at Completion	0.0%	27.5%	100.0%	72.5%
Cost Saving/Cost Overrun	0.0%	47.5%	100.0%	52.5%

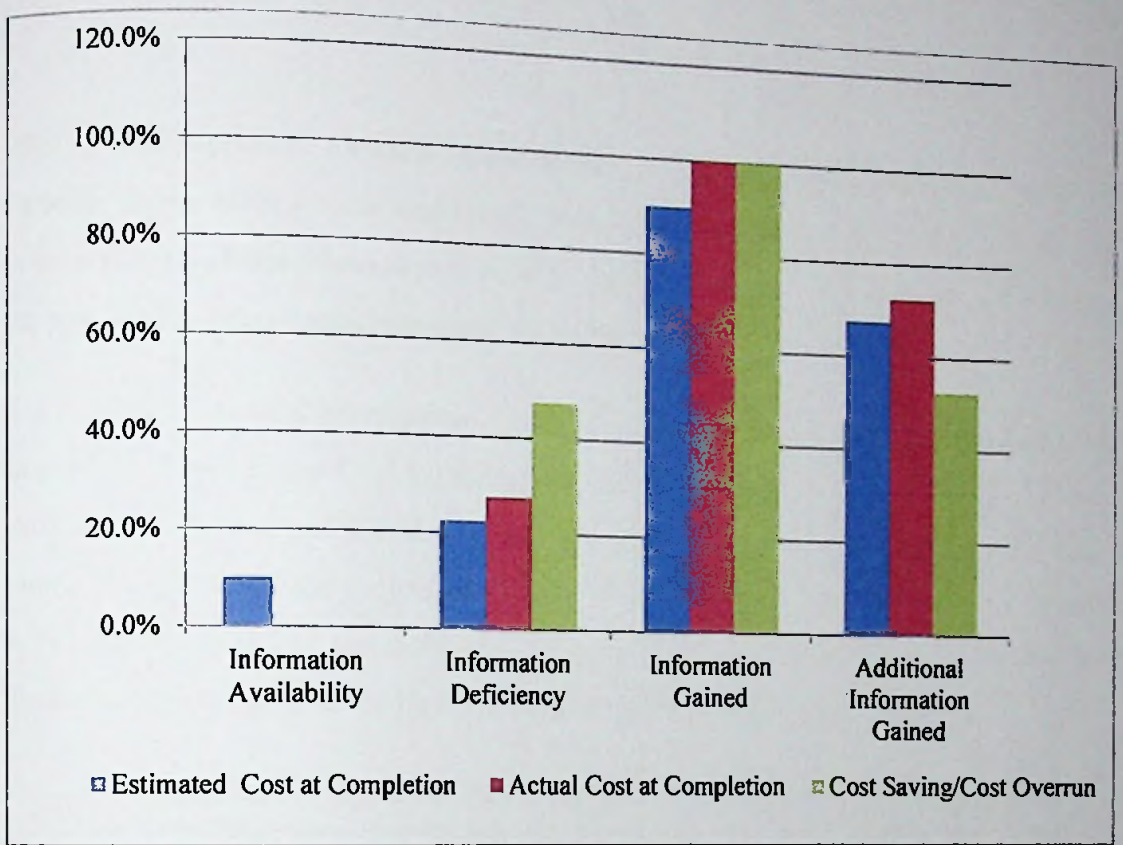


Figure 4.15: Project Forecast - Operational Level

Here also out of three activities defined in the ERP system that have major impact on project forecast estimated cost at completion is available with project team members. Information deficiency and gain varies from 22.5% to 47.5% and 90% to 100%.

The information deficiency and information gained based on data shown in Appendix B in the area of Project Forecast at Operational Level are 31.8% and 98% respectively.

Project Account and Financial Management - Managerial Level

Project account and financial management is importance to ensure that projects is completed on time and within budget. Project Accounting connects project activities with organizations financials, provides extensive reporting capabilities, helps ensure accurate accounting and billing processes throughout project life-cycles, and streamlines time and expense management. Further it facilitate accurate project costing and represent additional costs in the valuation of inventory handling, that are often unknown at the time of purchase order creation — into the total cost of goods.

ERP system support to Financial Management, accounting staff of DHQC for resolving various issues related with accounting and Financial Management aspects, reporting system that Facilitate implementation of the project and providing advisory services and support for financial management and other allied issues.

Account and Financial Management mainly focuses on income statement, is also called as profit and loss account, which reflects the operational position of the project during a particular period and position statement, is also called as balance sheet, which reflects the financial position of the project at the end of the financial year. Table 4.16 illustrates information availability and deficiency in terms of activities under Project Account and Financial Management while Figure 4.16 graphically presents the comparison.

Table 4.16: Project Account and Financial Management- Managerial Level

Process	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Petty Cash Report	20.0%	55.0%	80.0%	25.0%
Accounts Receivable	20.0%	50.0%	80.0%	30.0%
Accounts Payable	16.7%	45.8%	83.3%	37.5%
Supplier's account inquiry	25.0%	53.1%	75.0%	21.9%
Item Stock Value	50.0%	30.0%	50.0%	20.0%
Sales Values	50.0%	30.0%	50.0%	20.0%
Depreciation	0.0%	70.0%	100.0%	30.0%
Profit and Loss Statement	20.0%	50.0%	80.0%	30.0%
Balance Sheet	20.0%	50.0%	80.0%	30.0%
Indirect Expenses	25.0%	62.5%	75.0%	12.5%
Overheads	25.0%	62.5%	75.0%	12.5%



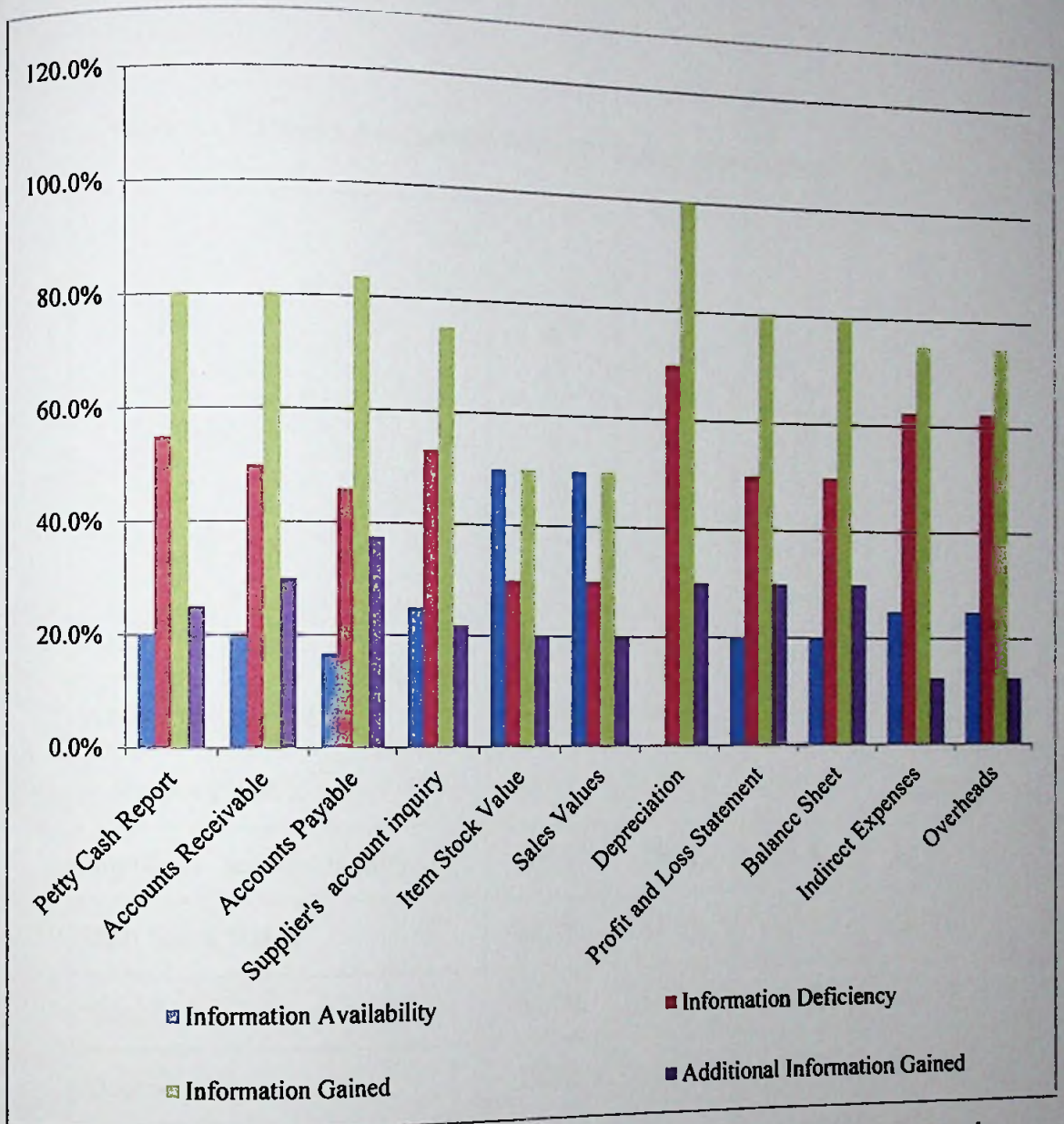


Figure 4.16: Project Account and Financial Management - Managerial Level

Information availability to project team members is minimal and varies from 0% to 50%. Information deficiency and gain varies from 30% to 62.5% and 50% to 100%. The information deficiency and information gained based on data shown in Appendix B in the area of Project Account and Financial Management at Managerial Level are 50.6% and 73.3% respectively.

Project Account and Financial Management - Operation Level

Table 4.17 illustrates information availability and deficiency in terms of activities under Project Forecast while Figure 4.17 graphically presents the comparison.

Table 4.17: Project Account and Financial Management - Operational Level

Process	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Petty Cash Report	33.3%	50.0%	66.7%	16.7%
Accounts Receivable	50.0%	50.0%	50.0%	0.0%
Accounts Payable	33.3%	41.7%	66.7%	25.0%
Supplier's account inquiry	8.3%	50.0%	91.7%	41.7%
Item Stock Value	66.7%	16.7%	33.3%	16.7%
Sales Values	66.7%	16.7%	33.3%	16.7%
Depreciation	0.0%	100.0%	100.0%	0.0%
Profit and Loss Statement	50.0%	50.0%	50.0%	0.0%
Balance Sheet	50.0%	50.0%	50.0%	0.0%
Indirect Expenses	33.3%	50.0%	66.7%	16.7%
Overheads	33.3%	50.0%	66.7%	16.7%

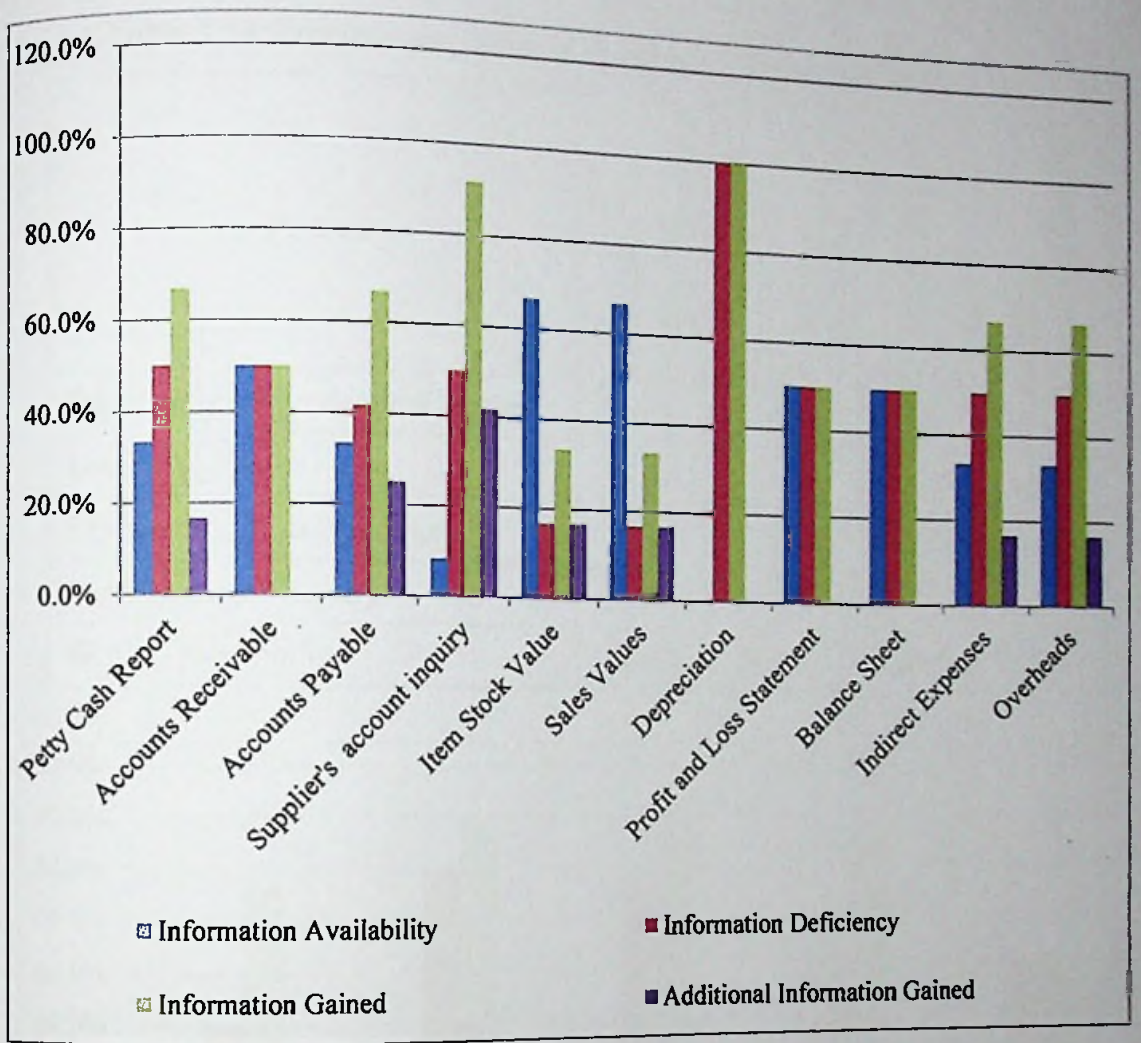


Figure 4.17: Project Account and Financial Management - Operational Level

Information availability to project team varies from 0% to 66.7%. Information deficiency and gain varies from 16.7% to 100% and 33.3% to 100%. The information deficiency and information gained based on data shown in Appendix B in the area of Project Account and Financial Management at Operational Level are 46.1% and 60.8% respectively.

Purchase and Stores Management - Managerial Level

Purchase and Stores Management is a vital part of project concern. Stock status of material and purchase order status are essential component to maintain stock level and to manage finances at optimum advantage. Table 4.18 illustrates information availability and deficiency in terms of activities under Purchase and Stores Management while Figure 4.18 graphically presents the comparison.

Table 4.18: Purchase and Stores Management - Managerial Level

Process	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Supplier's contact details/Category	23.1%	50.0%	76.9%	26.9%
Search material or item	11.4%	79.5%	88.6%	9.1%
Stock status of material/item	9.1%	79.5%	90.9%	11.4%
Purchase order inquiry	14.3%	62.5%	85.7%	23.2%
Work Order Inquiry	39.6%	60.4%	60.4%	0.0%

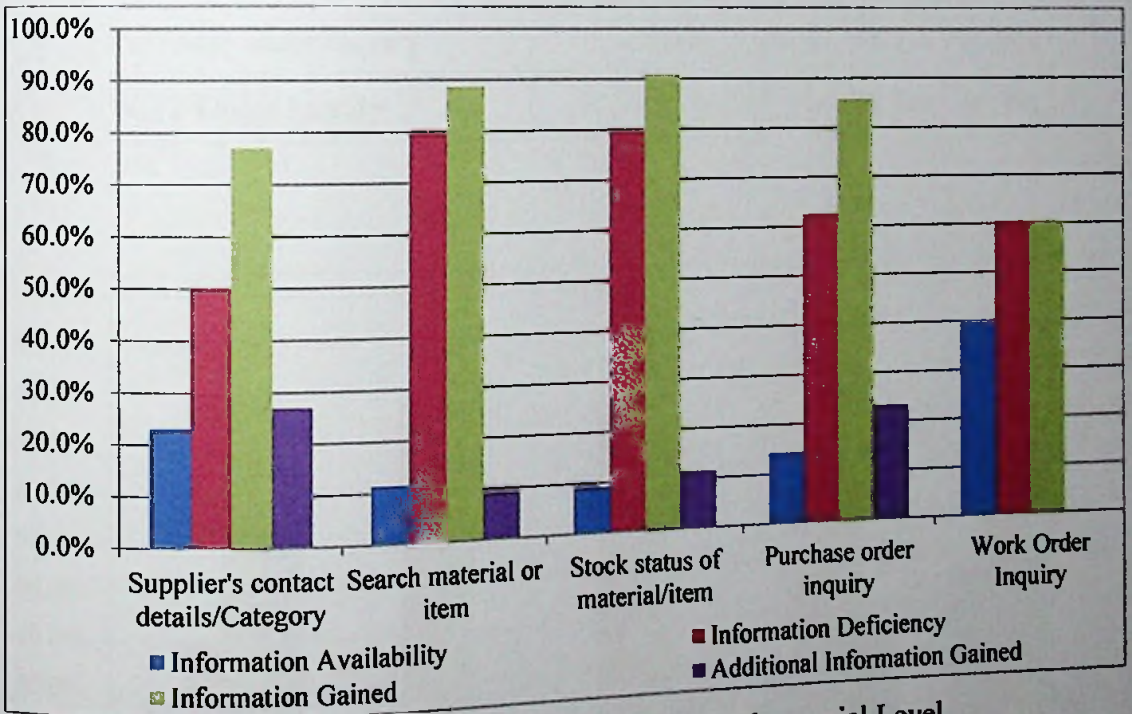


Figure 4.18: Purchase and Stores Management - Managerial Level

Information availability of Purchase and Stores Management to project team members varies from 9.1% to 39.6%. Information deficiency and gain varies from 50% to 79.5% and 60.4% to 90.9%. The information deficiency and information gained based on data shown in Appendix B in the area of Project Purchase and Stores Management at Managerial Level are 65.1% and 79.3% respectively.

Purchase and Stores Management - Operation Staff Level

Table 4.19 outlines information availability and deficiency in terms of activities under Purchase and Stores Management while Figure 4.19 graphically presents the comparison.

Table 4.19: Purchase and Stores Management - Operation Staff Level

Process	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Supplier's contact details/Category	18.2%	29.5%	81.8%	52.3%
Search material or item	11.1%	77.8%	88.9%	11.1%
Stock status of material/item	10.0%	77.5%	90.0%	12.5%
Purchase order inquiry	16.7%	60.4%	83.3%	22.9%
Work Order Inquiry	37.5%	52.1%	62.5%	10.4%

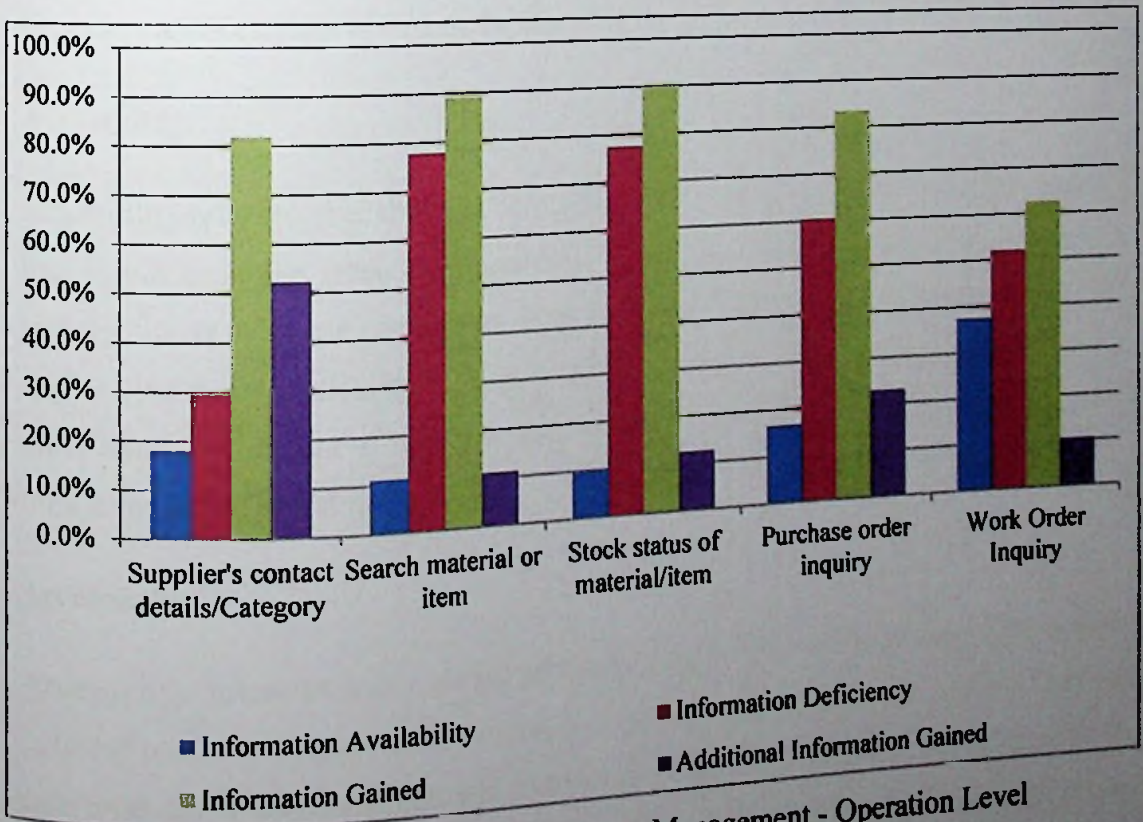


Figure 4.19: Purchase and Stores Management - Operation Level

Information availability of activities under Purchase and Stores Management to project team varies from 10% to 37.5%. Information deficiency and gain varies from 29.5% to 77.8% and 62.5% to 90%. The information deficiency and information gained based on data shown in Appendix B in the area of Purchase and Stores Management at Operational Level are 61.6% and 82.5% respectively.

4.5.4 Qualitative Data Appraisal in ERP System.

Quantitative data evaluation can be categorized as functional benefits of ERP system which is a quantitative appraisal. On implementation of ERP system to DHQC Project, Project team members were able to reap not only the functional benefits, but also non-functional benefits.

Non-functional benefits have been defined as Availability, Accessibility, Maintainability, Security, Documentation, Disaster recovery, Extensibility, Usability, Quality, Reliability, Response time, Robustness, Interoperability, Portability, Stability, Supportability, Capacity, and Testability (Levent, 2009).

Availability

Availability refers to availability of resources when it is required. An information system that is not available when it is needed it is almost similar to none at all. However, information is available somewhere in the particular enterprise. In computer hardware engineering terms availability is the probability a system is operational at a given time, in other terms the amount of time a device is actually operating as the percentage of total time it should be operating.

Accessibility

Accessibility refers to user's ability to access the system. In web-based ERP system fictional team members have the freedom to access system, update himself in terms of enterprise day-to-day functions, and monitor the progress of all activities irrespective of the location he access from. These help managers to take quick decisions using remote access facility of ERP and response quickly to queries made by team leaders. Therefore, managers do not have to be present in the office to identify the latest updates of the

project. They can plan the day work in advance by checking status and visualize work plan prior to reach office. Functional Team members also reap the same benefit having direct access to superiors when seeking advices.

Maintainability

Maintainability refers to the ability to change and modify the existing system or develop its functionalities and system performance. A fast and continuously changing business environment demands flexible ERP systems, which are easy to modify and maintain. Today many systems at an enterprise are interconnected and a change to one system may cause a ripple effect among the other systems. Therefore, goal of any enterprises is to implement flexible ERP systems to cater continuously changing business environment with minimum cost at later stage. Specific need can be introduced as a template and system has the facility to produce customized reports any time. Producing such reports manually consumes considerable time or sometimes those reports are impossible to bring into live.

Security

Protecting online assets of an organization is of highly important aspect in competitive business environment. Security requirement data is one of the most important factors of an ERP system. Restricting access features or data to certain users provide privacy of data entered into the system. Unauthorized person does not have the access to facilities defined other person as system has deferent security levels depending on the hierarchical levels and authorities entrusted by the enterprise, which is a mandatory criteria to run organization to the specified goal.

Documentation

Documentation means maintaining a set of documents on a paper or some other means such as online, audio tape or Compact Disk. It is an obvious fact that any organization needs to keep track on day-to-day actions and preserve monthly or yearly records to monitor enterprise benefits and performance measurements. Manual system encourages the enterprise to protect old data in a file cabinet, which considered as labour intensive

process and unsafe mode of data preservation. Some organizations are practicing maintenance of data in a master file in safe place and working copy at working place that serve as a back-up file or as a disaster recovery. In this case, there is an enormous risk of having organization's undisclosed data stolen by the competitors. This can be easily avoided by introducing enterprise-wide inter-functional coordination and integration through ERP implementation. Nevertheless, ERP deployment in an organization will be an effective tool to help manage the project throughout its life cycle. This help keep people focused and oriented in the same direction.

Disaster Recovery

Disaster recovery is ability to recover old data or continuation of technology infrastructure after natural or human made disaster. If something happen to ERP deployed in an Enterprise, all the activities will be out of focus. For that reason, it is important to have a complete, tested, disaster recovery plan for ERP system. Prior planning and preparation will be the most suited solution for disaster recovery. Disaster recovery planning involves two types of actions, which are identified as preventive action, and protective actions. In preventive action, it will protect the system in case of disaster, which includes such things as power protection, both with uninterruptable power supplies and providing redundant electric circuits to avoid a single point of failure. Another way of preventive action is use of redundant array of independent disk. Those disk drives employ two or more drive in combination for fault tolerance and performance.

Making backups is a standard best practice for any kind of IT operation. A disaster recovery backup is designed to restore entire ERP system, including the software. Cloud provides facilities for offsite backups. Web Based ERP system is also act as a disaster recovery off site backup (Cook, 2013).

Extensibility

Extensibility refers to the ability to expand the existing features or functionalities of ERP system, sometimes called product revision. This may be either addition of new functionality or enhancement of capabilities of an existing functionality. There are pros and cons in terms of extensibility depending on the enterprise requirements. One

organization needs an improvement in the business process, which will not be totally fit for other enterprise. However, ERP considered for case study has the extensibility to achieve enterprise requirements. It may produce templates of textual or arithmetic data into graphical representation, which enable user to analyze a situation and deduce conclusion at a glance.

Usability

Usability is the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction. Further, Usability is a part of usefulness and is composed of 'learn-ability' or user-friendliness. Market demand goes down if the product is not user-friendly. Therefore, vendors are meeting customer demands by upgrading their solutions with a wide range of capabilities that improve usability.

In presence of an ERP system, managers and executives need not to compile data derived from multiple data sources. In addition, ERP systems facilitate users to analyze their business performance on the fly and develop reports using simple drag & drop of the data or click of a button that is updated in real time with the flow of day-to-day operations.

4.5.5 Analysis Based on Expertise Knowledge

The purpose of analyzing expertizes knowledge is to enhance the validity and reliability or reconfirm the validation of data gather from selected case study. It is therefore essential to select the best-suited individuals who are capable of providing valuable information of contemporary phenomena under investigation. They possess PM skills viewing in broader aspect, experience in postwar reconstructions, and PM skills under heavily militarized situation.

- I. The expert professionals selected has at least 20 years of extensive PM experience in each of them
- II. Each of the experts have been engaged with either major Reconstruction Projects or Military Construction Projects during their career. Especially the selected military professionals were heavily engaged with Military

Construction and Reconstruction Projects which are mostly national projects during their service.

- III. The expert view on usage of IS for CPM was inadequate for them to provide with thorough viewpoint. However they have been using standalone software and utilities such as e-mail during their ventures. Also all of them emphasised the fact that Information Technology has made the Management aspects convenient for them. However the lack of hands-on experience with distributed systems for the experts made it difficult to obtain a comprehensive review.

With their expertise on construction, most of them emphasized their concern on following aspects.

- I. The extensive physical distance between project stake holders as a primary cause of delays in decision making
- II. Lack of project pre-planning, certainty concerning project process integration
- III. Lack of logistical support and suffering of continuous shortage of materials including supply chain management problems
- IV. Difficulty to procure and access materials and equipment had always made site's conditions a negative impact on productivity
- V. Misinterpretations and miscommunications of project results and need assessments
- VI. Lack of centralized decision-making process and lack of dedicated authority to field personnel often hinders progress and communications
- VII. Lack of a communications plan such as Who wants which reports, how often, in what format and using what media
- VIII. Difficulty of Identification of deliverables in the project
- IX. The main reason for most of the problems quoted by the project managers is the lack of integration and sharing of materials information across various functional departments

- X. Key management issues could be resolved by good communication management
- XI. Expertize in the construction industry emphasized the need of a reliable tool to track the progress of project help resolve most of the construction issues in terms of cost and time overrun
- XII. Need to access accurate up to date information at the point of activity reducing the cost of remedial work through doing it right first time
- XIII. Identification of materials enabling faster location selection reducing wasted materials through loss, damage or oversupply
- XIV. Non-Availability of accurate real-time progress and cost information which can inform later project stages and/or future projects.
- XV. Need of a reliable tool to provide fast feedback to the site personnel regarding the most problematic construction problems such as these related to the monitoring of the construction process, quality of work, procurement of materials and productivity levels

4.6 SUMMARY

Data were analysed under two platforms to avoid omission of valuable outcomes and to merge them for meaningful conclusion.

- I. Analysis of time - Analysis based on time taken to process an activity prior and after implementation of ERP
- II. Project Data Availability to Project Team Members

Time benefit was considered under six subject groups; Asset Management, Cost Management, Time Management, Project Forecast, Account and Financial Management and Procurement and Stores Management. Out of more than 200 functions in the ERP System, only the data set, which has major impact on the project, is captured under selected set of processes/areas.

Literature review available to assure that automating business processes such as invoicing and sales and purchases within one system improves forecasting accuracy and reduces inefficiencies.

In the current system, some data are not available with project managers or their staff at all. Even if available data are accessible for limited number of functional group members, others are unaware of up to date data sources. Such problems can introduce significant and unpredictable delays in the access of information from remote sources. ERP system provides potential benefits to bridge the gap.

Secondly, project data availability to project team members was analyzed under same six subject groups to evaluate the benefit of implementing ERP system. The tables and graphs clearly show information deficiency and gain that are derived from availability and minimum requirement of information to project team members. It expresses both managerial and operational staff are almost equally benefited after implementation of ERP system

Thirdly, Non-functional benefits such as Availability, Accessibility, Maintainability, Security, Documentation, Disaster recovery, Extensibility, Usability, Quality, Reliability, Response time, Robustness, Interoperability, Portability, Stability, Supportability, Capacity, and Testability were also explored in addition to qualitative data appraisal.

In a Summary, the chapter is concluded with a comprehensive identification benefit of implementing ERP system to move forward towards the conclusion and recommendation.

CHAPTER 5 - CONCLUSIONS AND RECOMMENDATION

5.1 RESEARCH CONCLUSION

This study focuses on benefits which can be achieved by implementing an ERP system in a construction project in the areas of Assets Management, Cost Management, Time Management, Project Forecast, Project Account and Financial Management and Purchase & Stores Management. Further, it is known through the literature that Time, Cost and Budget are the main pillars of PM, hence increasing the information depth on these aspects would evidently increase the efficiency of CPM. Results of this study are presented in two areas namely time benefit and information availability.

Asset Management

Viewing All Assets Registry, Finding Assets Location, Work Center Details, and Asset Maintenance Cost are the four parameters discuss under Asset Management. Awareness of available assets, locations where those assets are deployed and maintenance cost are important for effective planning and controlling a project. Time reduction, information deficiency and gained are tabulated below.

Table 5.1: Time Benefit, Information Deficiency and Gained of Asset Management

Functional Levels	Time Reduction	Information Deficiency	Information Gained
Managerial Level	88.5%	67.2%	90.6%
Operational Level	88.2%	41.3%	92%

Time saving to access data is of an enormous benefit, helps faster construction processes, and improves efficiency. Literature also provides sufficient evidence to prove that ERP produces results more quickly and easier and improve asset management.

The case study shows that project runs with severe shortage of information, which creates negative impact on successful PM. This shows more information is required for Operational Level than Managerial Level to run the project.

Supportive comments for the benefit of efficient Asset Management were obtained from the expert views also. Especially the experts with military background emphasized that proper asset registries and quick access were never available to them even during war period, thus utilizing military assets optimally was denied during critical events.

Cost Management

An implementation of ERP considerably save the time consumes for day-to-day processes of project team members. Five processes are considered at Cost Management. Out of these five processes, CPI value defined in the EVM is a powerful tool used in construction industry to assess the project performance. Lot of studies has been done to prove that CPI provides reliable early warning for project managers to implement counteractive actions.

After implementation of ERP, data availability and accessibility to project team members are significantly improved.

Table 5.2: Time Benefit, Information Deficiency and Gained of Cost Management

Functional Levels	Time Reduction	Information Deficiency	Information Gained
Managerial Level	94.8%	55.5%	86.2%
Operational Level	94.5%	29.8%	87.1%

CPI value is readily available with every project team members to judge progress of project. Therefore, organization gets enough time to implement any corrective action in advance and to prepare for the future. Availability of centralized database is of immense use for management to analyze the situation and achieve more precise and accurate decisions. Therefore, centralized databases and built-in data analysis capabilities are ideally placed in the ERP to provide decision and planning benefits to management.

Expertize in the construction industry emphasize presence of reliable tool to track the progress of project help resolve most of the construction issues in terms of cost and time overrun. In that sense ERP is a valuable IT solution for Cost Management. The experts who had full experience in reconstruction and rehabilitation projects stressed the

importance of cost management. They were impressed by the facilities in the system to do an Earn Value Analysis real time.

Researchers point out that SPI becomes unreliable when the project moves towards last third of project life cycle. SPI becomes one when Earned Value and Planed Value are equal. SPI loses the predictive ability when the project runs as planed and at the end of the project as well.

Time Management

Four parameters debated under Time Management are Total Budget Value as per Schedule, Total Budget Value of Completed Items, Schedule Performance Index (SPI), Schedule Performance Measurement on Value of Work, and Schedule Performance on Time as per Total Duration in Days. Schedule performance that brings early indication of the project performance is the most significant parameters discussed under Time Management and SPI ranks top position.

Author believes that material supply, human resource, construction drawings, construction planning and plant & machinery are key contributing factors for the performance of project. Since SPI brings early indication of project performance, it enables Project Manager to identify what areas are to be focused more to put the project back into track. Manual processes do not bring satisfactory results as team members are engaged in other project activities and do not find sufficient time to undertake such tasks. ERP system makes available data to project team through built-in data analysis. This opportunity can be used to obtain an early warning so as to implement counteractive measures in advance.

Table 5.3: Time Benefit, Information Deficiency and Gained of Time Management

Functional Levels	Time Reduction	Information Deficiency	Information Gained
Managerial Level	92.3%	66%	94.5%
Operational Level	90.2%	41.5%	93.3%

Further, the experts also elaborated on the critical timelines they receive to complete mainly military construction projects. Further experts who are serving in the military explained that most of the time critical construction projects have been handed over to the military mainly because of the belief that military can handle time critical projects. So the ERP system clearly provides with better means of management for time critical projects.

Time reduction help gain benefit through inventory reduction, work force reduction, improved monitoring efficiency while information availability provides benefits especially in the area of project predicting as previously mentioned.

Project Forecast

Among three subjects discuss under project forecast the item "Cost at Completion" or "Estimate at Completion" and Cost saving / overrun are the most significant and determinant factors of projects. However, other factor, Estimated Cost at Completion, which is prepared at the inception of project, cannot be ignored as it acts as base line for comparison of other two dimensions.

Table 5.4: Time Benefit, Information Deficiency and Gained of Forecast Management

Functional Levels	Time Reduction	Information Deficiency	Information Gained
Managerial Level	95.4%	67.4%	95.6%
Operational Level	95.7%	31.8%	98.0%

Percentages of time reduction of Project Forecast in Managerial and Operational Level give very high values. Shang and Seddon (2002) benefit framework also provide

evidence for centralized databases and built-in data analysis capabilities provide decision and planning benefits to management reducing cycle time.

The experts commented that even with a system such as an ERP, project forecasting would be difficult in reconstruction projects because of the complexity of stake holders. But case study outcome proves that not only managerial level but also operational level staffs reap benefit alike. Availability of information to both Managerial and Operational level improves decision-making, productivity, and performance improvement in a variety of ways in all levels.

Project Account and Financial Management

Project Account and Financial Management constitute of eleven sub divisions, which include Petty Cash Report, Accounts Receivable, Accounts Payable, Supplier's account inquiry, Item Stock Value, Sales Values, Depreciation, Profit and Loss Statement, Balance Sheet, Indirect Expenses, and Overheads. All these factors are of utmost importance to achieve organizational goal.

Table 5.5: Time Benefit, Information Deficiency and Gained of Financial Management

Functional Levels	Time Reduction	Information Deficiency	Information Gained
Managerial Level	86.9%	50.6%	73.3%
Operational Level	86.8%	46.1%	60.8%

The time saving leads to Personnel Reduction, Cash Management Improvement, Improved decision making and planning and Productivity Improvements.

The experts view on efficient financial management are focused on cash flow management and cost control. Most of them elaborated the facts that cash flow of a project is critical for continuity of the construction process. Since most of the budget for projects are allocated from certain ministries or government entities, project managers should be fully aware of the cash flow with reference to initial budget. In contrary military experts mentioned that during the wartime most of the construction projects were carried out without any cash flow monitoring.

Case study shows significant percentage increase in accessibility to data for both Managerial and Operational Level, which improve monitoring efficiency, reporting, communication, accurate decision-making and better performance monitoring, inventory reduction and cash management. Literature review also provides sufficient evidence to prove this statement.

Purchase and Stores Management

Purchase and Stores Management constitute of four sub divisions, which include supplier's contact details / category, search material or item, stock status of material / item, purchase order inquiry.

Construction materials usually constitute a major portion of the total cost in a building construction project. Stores Management is made problematic by materials shortages, delays in supply, price fluctuations, damages, wastage, and lack of storage space. Supplier's details and stock status are equally important in Purchase and Stores Management in order to get better service from suppliers and to maintain stock levels. Timely availability of data among project team members reduces most of the issues.

Table 5.6: Time Benefit, Information Deficiency and Gained of Stores Management

Functional Levels	Time Reduction	Information Deficiency	Information Gained
Managerial Level	83.9%	65.1%	79.3%
Operational Level	83.4%	61.6%	82.5%

Reduction of time improves Reporting Efficiency, Communication, Inventory Reduction, Procurement Cost Reduction and finally converging to overall cost reduction in the process of Purchase and Stores Management.

The experts clearly mentioned that stores management is very critical and optimizing the stores will always benefit in areas of man power, store space, cash flow management and

material quality. So they were impressed by the facilities in the system to monitor and optimize the stock levels and purchasing.

Improvement in accessibility to data under consideration is very useful in getting the right quality & right quantity of supplies at right time, having good inventory control. Thus, those factors help improve the efficiency and productivity of the organization and make the working atmosphere healthy.

The productivity improvement and information availability in postwar construction that can be achieved with IS in percentages can be tabulated as follows.

Table 5.7: Efficiency Increase in Percentages

Management Functions	Managerial Level			Operational Level		
	Time Reduction	Information Deficiency	Increase of Information Depth	Time Reduction	Information Deficiency	Increase of Information Depth
Asset	88.50%	67.20%	90.60%	88.20%	41.30%	92.00%
Cost	94.80%	55.50%	86.20%	94.50%	29.80%	87.10%
Time	92.30%	66.00%	94.50%	90.20%	41.50%	93.30%
Reporting	95.50%	67.4%	95.60%	95.70%	31.80%	98.00%
Finances	86.90%	50.60%	73.30%	86.80%	46.10%	60.80%
Stores	83.90%	65.10%	79.30%	83.40%	61.60%	82.50%

The values presented in the above tabulation summarize the analysis followed in the data analysis phase. It clearly illustrates the efficiency increase that can be achieved with the use of a Distributed Information System for CPM. Further, these outcomes were strengthened with the comprehensive analysis of expert interviews. Use of IT in CPM, though the concept is groundbreaking for the Sri Lankan context, can improve the efficiency and contribute to better PM. Above outcome provide evidence that use of IT improves the productivity making information available for project team members in the

areas of Assets Management, Cost Management, Time Management, Project Forecast, Project Account and Financial Management and Stores Management.

5.2 RECOMMENDATION

Sri Lanka has not fully realised the benefits of IT. Therefore, the Infrastructure for IT as a whole is not very satisfactory. Construction industry lacks IT and its infrastructures and situation gets worse in rural areas. Author believes that it is high time for Sri Lankan construction industry to manage construction projects with IT to operate at optimum advantage. This study identifies the benefit for project team members to access project data and availability of such data after implementation of ERP. Advantages achieved by adoption of ERP in construction project include but not limited to less paper work specially ordering materials, cycle time reduction, less duplication, better resource management, on time delivery, improved information sharing efficiency, personnel reduction, quality improvement, cash management improvement, better aligned cross-departmental processes, improved decision making and planning which finally accrue as productivity improvement and cost saving of the project.

Even though it is clear that postwar construction management should be IT oriented to improve productivity, there can be a risk of IT projects failures. IT projects have a larger failure rate than other projects. Therefore a strong level of PM should be incorporated in implementation of ERP projects. It is also important to give an overall ERP knowledge to the construction team which should be taken care of with long term expectation.

Implementation of ERP is also separate projects which require lot of inputs from project team members. But efforts of project team focus towards primary task of completing main project rather than committing their effort for implementation of ERP. Thus backing of all team members is very essential part especially at the initial implementation stage. ERP systems require individuals to learn, understand and master the system.

However, many project team members do not make this effort. Most of them like to continue with what they have been doing and they have a fear that changes may impact adversely on their work practices.

Further, open source ERP or proprietary products do not perfectly fit to construction process. Business Process Re-engineering (BPR) should be considered prior to adoption of ERP or IT project in Sri Lankan postwar construction.

This study is done through a very narrow perspective which focuses on productivity and information availability for the project team members after adoption of ERP in a postwar construction project. Bigger scope is required to identify factors which contribute to the relationship between ERP and specific project performance outcomes to help make a clear vision and roadmap of the benefits of ERP.

5.3 FURTHER RESEARCH

Very few researches are available in postwar construction to build a strong body of evidence and to analysis about the productivity improvement by implementation of ERP. Hence researches in the areas of Social, Technical, Psychological and Management aspects are to be done to identify overall benefits of ERP.

Introduction of an ERP system to a workplace is introduction of a completely new work culture. Good Leadership is a key to the success of ERP adoption. Existing organizational culture plays an important role during implementation of ERP systems and consequently its success. People's attitude towards new changes is to be analysed prior to replace existing systems with ERP.

One of the main problems in introducing IT system to a work place is due to the facts that bulk of the workforce, particular the senior hands, are not computer literate. Instinctively they tend to resist introduction of any system that may make them obsolete or irrelevant. This situation soon changes for the better since all schools have computer education as part of their curricular.

Occasionally projects are entrusted to military with predefined project durations which are sometimes unachievable. In such situations, the biggest challenge faced by military is planning and organizing resources within short period. Hence military projects require the interaction and coordination of various stakeholders during all stages of the project life cycle. Different project teams are often geographically separated and operate in



isolation without knowing what is happening in other project. As a result, there is excess of labour and idling machinery at one site which another site is in need of both. Implementation of an ERP system would provide the tools for efficient management of all resources. The author believes that only viable option is to implement an integrated information system but very little research is available in this area to support this statement.

Sri Lanka is not a fully-fledged computer user. Issues such as the high relative cost of hardware and software pared to costs in the West, limited national infrastructure and difficulties with IT Implementation projects has led to relatively low adoption of ERP in Sri Lanka. Computer literacy in Sri Lanka is very low though the computer, internet and e-mail have been around in households, work places schools and universities for last two decades in the country. Further studies of above aspects also to be done to reap overall benefit of ERP.

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Process	Managerial Level							Operational Level						
	Duration Taken for Manual Operation in Minutes	Duration Taken after ERP Implementation in Minutes	Percentage of Time Reduction	Frequency of Occurrences	Sum of Frequency of Occurrences	Percentage of Time Reduction Weighted in Frequency of Occurrences of Managerial Level	Sum of Percentage of Time Reduction	Duration Taken for Manual Operation in Minutes	Duration Taken after ERP Implementation in Minutes	Percentage of Time Reduction	Frequency of Occurrences	Sum of Frequency of Occurrences	Percentage of Time Reduction Weighted in Frequency of Occurrences of Operational Level	Sum of Percentage of Time Reduction
Assets Management							88.5%							88.2%
Viewing All Assets Registry	45	8	82.2%	3.36	17.86	15.5%		45	8	82.2%	0.69	7.44	7.6%	
Finding Assets Location	35	6	82.9%	5.50	17.86	25.5%		35	6	82.9%	3.38	7.44	37.6%	
Work Center Details	45	5	88.9%	3.56	17.86	17.7%		45	5	88.9%	1.21	7.44	14.5%	
Asset Maintenance Cost	240	5	97.9%	5.44	17.86	29.8%		240	5	97.9%	2.17	7.44	28.5%	
Cost Management							94.8%							94.5%
Cost of BOQ Items	50	4	92.0%	1.9167	14.358	12.3%		50	4	92.0%	0.85	3.7243	21.0%	
Resource Variation Cost due to Wastages	150	8	94.7%	1.9167	14.358	12.6%		150	8	94.7%	0.8889	3.7243	22.6%	
Cost due to Price Variation (Purchases Vs Estimated)	120	6	95.0%	2.375	14.358	15.7%		120	6	95.0%	0.4167	3.7243	10.6%	
Cost of BOQ Items Completed	80	4	95.0%	4.1667	14.358	27.6%		80	4	95.0%	0.8	3.7243	20.4%	

Cost Performance Index (CPI)	240	6	97.5%	1.4	14.358	9.5%		240	6	97.5%	0.3438	3.7243	9.0%	
Project Income from BOQ Items	100	5	95.0%	2.5833	14.358	17.1%		100	5	95.0%	0.425	3.7243	10.8%	
Time Management							92.3%							90.2%
Total Budget Value as per Schedule	20	3	85.0%	1.3333	6.8667	16.5%		20	3	85.0%	0.275	1.3833	16.9%	
Total Budget Value of Completed Items	25	3	88.0%	1.8333	6.8667	23.5%		25	3	88.0%	0.65	1.3833	41.3%	
Schedule Performance Index (SPI)	240	5	97.9%	2.2	6.8667	31.4%		240	5	97.9%	0.125	1.3833	8.8%	
Schedule Performance measurement on Value of Work	120	5	95.8%	0.75	6.8667	10.5%		120	5	95.8%	0.1667	1.3833	11.5%	
Schedule Performance on Time as per Total Duration in Days	120	5	95.8%	0.75	6.8667	10.5%		120	5	95.8%	0.1667	1.3833	11.5%	
Project Forecast							95.5%							95.7%
Estimated Cost at Completion	90	5	94.4%	1.2083	4.5417	25.1%		90	5	94.4%	0.3	1.5	18.9%	
Actual Cost at Completion	120	4	96.7%	2	4.5417	42.6%		120	4	96.7%	0.8	1.5	51.6%	
Cost Saving/Cost Overrun	110	6	94.5%	1.3333	4.5417	27.8%		110	6	94.5%	0.4	1.5	25.2%	
Project Account and Financial Mangement							86.9%							86.8%
Petty Cash Report	45	6	86.7%	10.8	89.35	10.5%		45	6	86.7%	8	55	12.6%	
Accounts Receivable	40	5	87.5%	10.8	89.35	10.6%		40	5	87.5%	10.5	55	16.7%	
Accounts Payable	45	5	88.9%	10.5	89.35	10.4%		45	5	88.9%	8	55	12.9%	
Supplier's account inquiry	45	7	84.4%	7.5	89.35	7.1%		45	7	84.4%	3.5	55	5.4%	
Item Stock Value	25	6	76.0%	8.4	89.35	7.1%		25	6	76.0%	5	55	6.9%	
Sales Values	45	7	84.4%	9.8	89.35	9.3%		45	7	84.4%	4	55	6.1%	
Depreciation	55	7	87.3%	3.6	89.35	3.5%		55	7	87.3%	3	55	4.8%	
Profit and Loss Statement	40	6	85.0%	1.6	89.35	1.5%		40	6	85.0%	1	55	1.5%	

Balance Sheet	60	6	90.0%	1.6	89.35	1.6%		60	6	90.0%	1	55	1.6%	
Indirect Expenses	60	5	91.7%	15	89.35	15.4%		60	5	91.7%	6	55	10.0%	
Overheads	50	5	90.0%	9.75	89.35	9.8%		50	5	90.0%	5	55	8.2%	
Purchase and Stores Management							83.9%							83.4%
Supplier's contact details/Category	40	6	85.0%	14.846	66.346	19.0%		40	6	85.0%	12.455	65.588	16.1%	
Search material or item	25	5	80.0%	10.545	66.346	12.7%		25	5	80.0%	20.333	65.588	24.8%	
Stock status of material/item	45	4	91.1%	12.455	66.346	17.1%		45	4	91.1%	11.8	65.588	16.4%	
Purchase order inquiry	25	5	80.0%	13	66.346	15.7%		25	5	80.0%	10	65.588	12.2%	
Work Order Inquiry	35	6	82.9%	15.5	66.346	19.4%		35	6	82.9%	11	65.588	13.9%	

Process	Managerial Level						Subject Area	Managerial Level			
	Average frequency of occurrences	Cumulative Frequency of Occurrences	Information Availability	Information Deficiency	Information Gained	Additional Information Gained		Information Availability	Information Deficiency	Increase of Information Depth	Additional Information Gained
Viewing All Assets Registry	3.36	17.86	16.7%	68.8%	83.3%	14.6%	Assets Management	9.4%	67.2%	90.6%	23.4%
Finding Assets Location	5.50	17.86	16.7%	70.8%	83.3%	12.5%					
Work Center Details	3.56	17.86	5.6%	61.1%	94.4%	33.3%					
Asset Maintenance Cost	5.44	17.86	0.0%	66.7%	100.0%	33.3%					

Process	Operational Level						Subject Area	Operational Level			
	Average frequency of occurrences	Cumulative Frequency of Occurrences	Information Availability	Information Deficiency	Information Gained	Additional Information Gained		Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Viewing All Assets Registry	0.69	7.44	12.5%	46.9%	87.5%	40.6%	Assets Management	8.0%	41.3%	92.0%	50.7%
Finding Assets Location	3.38	7.44	12.5%	46.9%	87.5%	40.6%					
Work Center Details	1.21	7.44	7.1%	32.1%	92.9%	60.7%					
Asset Maintenance Cost	2.17	7.44	0.0%	36.1%	100.0%	63.9%					

Cost Management

Process	Managerial Level						Managerial Level				
	Average frequency of occurrences	Cumulative Frequency of Occurrences	Information Availability	Information Deficiency	Information Gained	Additional Information Gained	Subject Area	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Cost of BOQ Items	1.92	14.36	41.7%	27.1%	58.3%	31.3%	Cost Management	13.8%	55.5%	86.2%	30.7%
Resource Variation Cost due to Wastages	1.92	14.36	0.0%	60.4%	100.0%	39.6%					
Cost due to Price Variation (Purchases Vs Estimated)	2.38	14.36	0.0%	75.0%	100.0%	25.0%					
Cost of BOQ Items Completed	4.17	14.36	16.7%	50.0%	83.3%	33.3%					
Cost Performance Index (CPI)	1.40	14.36	0.0%	92.5%	100.0%	7.5%					
Project Income from BOQ Items	2.58	14.36	18.8%	43.8%	81.3%	37.5%					

Cost Management

Process	Operational Level						Operational Level				
	Average frequency of occurrences	Cumulative Frequency of Occurrences	Information Availability	Information Deficiency	Information Gained	Additional Information Gained	Subject Area	Information Availability	Information Deficiency	Information Gained	Additional Information Gain
Cost of BOQ Items	0.85	3.72	30.0%	17.5%	70.0%	52.5%	Cost Management	12.9%	29.8%	87.1%	57.3%
Resource Variation Cost due to Wastages	0.89	3.72	0.0%	50.0%	100.0%	50.0%					
Cost due to Price Variation (Purchases Vs Estimated)	0.42	3.72	0.0%	37.5%	100.0%	62.5%					
Cost of BOQ Items Completed	0.80	3.72	20.0%	25.0%	80.0%	55.0%					
Cost Performance Index (CPI)	0.34	3.72	0.0%	25.0%	100.0%	75.0%					
Project Income from BOQ Items	0.43	3.72	15.0%	17.5%	85.0%	67.5%					

Time Management

Process	Managerial Level						Subject Area	Managerial Level			
	Average frequency of occurrences	Cumulative Frequency of Occurrences	Information Availability	Information Deficiency	Information Gained	Additional Information Gained		Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Total Budget Value as per Schedule	1.33	6.87	16.7%	43.8%	83.3%	39.6%	Time Management	5.5%	66.0%	94.5%	28.6%
Total Budget Value of Completed Items	1.83	6.87	8.3%	58.3%	91.7%	33.3%					
Schedule Performance Index (SPI)	2.20	6.87	0.0%	95.0%	100.0%	5.0%					
Schedule Performance measurement on Value of Work	0.75	6.87	0.0%	57.5%	100.0%	42.5%					
Schedule Performance on Time as per Total Duration in Days	0.75	6.87	0.0%	47.5%	100.0%	52.5%					

Time Management

Process	Operational Level						Subject Area	Operational Level			
	Average frequency of occurrences	Cumulative Frequency of Occurrences	Information Availability	Information Deficiency	Information Gained	Additional Information Gained		Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Total Budget Value as per Schedule	0.28	1.38	10.0%	22.5%	90.0%	67.5%	Time Management	6.7%	41.5%	93.3%	51.9%
Total Budget Value of Completed Items	0.65	1.38	10.0%	55.0%	90.0%	35.0%					
Schedule Performance Index (SPI)	0.13	1.38	0.0%	34.4%	100.0%	65.6%					
Schedule Performance measurement on Value of Work	0.17	1.38	0.0%	33.3%	100.0%	66.7%					
Schedule Performance on Time as per Total Duration in Days	0.17	1.38	0.0%	33.3%	100.0%	66.7%					

Project Forecast

Managerial Level							Managerial Level				
Process	Average frequency of occurrences	Cumulative Frequency of Occurrences	Information Availability	Information Deficiency	Information Gained	Additional Information Gained	Subject Area	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Estimated Cost at Completion	1.21	4.54	16.7%	52.1%	83.3%	31.3%	Project Forecast	4.4%	67.4%	95.6%	28.2%
Actual Cost at Completion	2.00	4.54	0.0%	68.8%	100.0%	31.3%					
Cost Saving/Cost Overrun	1.33	4.54	0.0%	79.2%	100.0%	20.8%					

Project Forecast

Operational Level							Operational Level				
Process	Average frequency of occurrences	Cumulative Frequency of Occurrences	Information Availability	Information Deficiency	Information Gained	Additional Information Gained	Subject Area	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Estimated Cost at Completion	0.30	1.5	10.0%	22.5%	90.0%	67.5%	Project Forecast	2.0%	31.8%	98.0%	66.2%
Actual Cost at Completion	0.80	1.5	0.0%	27.5%	100.0%	72.5%					
Cost Saving/Cost Overrun	0.40	1.5	0.0%	47.5%	100.0%	52.5%					

Purchase and Stores Management

Process	Managerial Level						Subject Area	Managerial Level			
	Average frequency of occurrences	Cumulative Frequency of Occurrences	Information Availability	Information Deficiency	Information Gained	Additional Information Gained		Information availability	Information deficiency	Information gained	Additional information gained
Supplier's contact details/Category	14.85	66.35	23.1%	50.0%	76.9%	26.9%	Purchase and Stores Management	20.7%	65.1%	79.3%	14.2%
Search material or item	10.55	66.35	11.4%	79.5%	88.6%	9.1%					
Stock status of material/item	12.45	66.35	9.1%	79.5%	90.9%	11.4%					
Purchase order inquiry	13.00	66.35	14.3%	62.5%	85.7%	23.2%					
Work Order Inquiry	15.50	66.35	39.6%	60.4%	60.4%	0.0%					

Purchase and Stores Management

Process	Operational Level						Subject Area	Operational Level			
	Average frequency of occurrences	Cumulative Frequency of Occurrences	Information Availability	Information Deficiency	Information Gained	Additional Information Gained		Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Supplier's contact details/Category	12.45	65.59	18.2%	29.5%	81.8%	52.3%	Purchase and Stores Management	17.5%	61.6%	82.5%	20.9%
Search material or item	20.33	65.59	11.1%	77.8%	88.9%	11.1%					
Stock status of material/item	11.80	65.59	10.0%	77.5%	90.0%	12.5%					
Purchase order inquiry	10.00	65.59	16.7%	60.4%	83.3%	22.9%					
Work Order Inquiry	11.00	65.59	37.5%	52.1%	62.5%	10.4%					

Project Account and Financial Mangement

Managerial Level							Managerial Level				
Process	Average frequency of occurrences	Cumulative Frequency of Occurrences	Information Availability	Information Deficiency	Information Gained	Additional Information Gained	Subject Area	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Petty Cash Report	10.80	89.35	20.0%	55.0%	80.0%	25.0%	Project Account and Financial Man	26.7%	50.6%	73.3%	22.7%
Accounts Receivable	10.80	89.35	20.0%	50.0%	80.0%	30.0%					
Accounts Payable	10.50	89.35	16.7%	45.8%	83.3%	37.5%					
Supplier's account inquiry	7.50	89.35	25.0%	53.1%	75.0%	21.9%					
Item Stock Value	8.40	89.35	50.0%	30.0%	50.0%	20.0%					
Sales Values	9.80	89.35	50.0%	30.0%	50.0%	20.0%					
Depreciation	3.60	89.35	0.0%	70.0%	100.0%	30.0%					
Profit and Loss Statement	1.60	89.35	20.0%	50.0%	80.0%	30.0%					
Balance Sheet	1.60	89.35	20.0%	50.0%	80.0%	30.0%					
Indirect Expenses	15.00	89.35	25.0%	62.5%	75.0%	12.5%					
Overheads	9.75	89.35	25.0%	62.5%	75.0%	12.5%					

Project Account and Financial Mangement

Operational Level							Operational Level				
Process	Average frequency of occurrences	Cumulative Frequency of Occurrences	Information Availability	Information Deficiency	Information Gained	Additional Information Gained	Subject Area	Information Availability	Information Deficiency	Information Gained	Additional Information Gained
Petty Cash Report	8.00	55	33.3%	50.0%	66.7%	16.7%	Project Account and Financial Man	39.2%	46.1%	60.8%	14.8%
Accounts Receivable	10.50	55	50.0%	50.0%	50.0%	0.0%					
Accounts Payable	8.00	55	33.3%	41.7%	66.7%	25.0%					
Supplier's account inquiry	3.50	55	8.3%	50.0%	91.7%	41.7%					
Item Stock Value	5.00	55	66.7%	16.7%	33.3%	16.7%					
Sales Values	4.00	55	66.7%	16.7%	33.3%	16.7%					
Depreciation	3.00	55	0.0%	100.0%	100.0%	0.0%					
Profit and Loss Statement	1.00	55	50.0%	50.0%	50.0%	0.0%					
Balance Sheet	1.00	55	50.0%	50.0%	50.0%	0.0%					
Indirect Expenses	6.00	55	33.3%	50.0%	66.7%	16.7%					
Overheads	5.00	55	33.3%	50.0%	66.7%	16.7%					