**ASSESSING RISK FACTORS AND THEIR EFFECTS ON THE PROJECT LIFECYCLE INCLUDING MEGAPROJECTS**

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**CHAPTER 1**

**1.0 INTRODUCTION**

Infrastructure projects and megaprojects (InPMps) are designed and developed to transform the structure of a society. They are unique, often with complex design, construction methods, and with a budget running into millions and billions of dollars. ([Juliano](https://journals.sagepub.com/action/doSearch?target=default&ContribAuthorStored=Denicol%2C+Juliano) 2020) called them the framework for producing large-scale, complex, and a one-off capital investments in an array of public and private sectors, been recognized for their risky ventures, InPMps can be difficult to manage and often fail to achieve their main goals. (Flyvbjerg, 2014) noted that InPMps are large-scale, complex infrastructures that typically cost above US$ 1 million, little less than US$1 billion or more, they take several years to develop and build, they involve multiple public and private stakeholders, they are transformational, and impact millions of people. Hirschman (1995) further defined InPMps as the development process designed to ambitiously change the structure of a society while Oluwole (2018), stated that InPMps evolve as an indelible legacy of the people who dared enormous obstacles and the ambition to find solutions to complex problems of a sheer size. In a risk factor perspective, Zhai et al. (2009) identified that InPMps exhibits extreme complexity, substantial risks, long delivery timeline, have an extensive impact on the community, economy, technological development, and in the sited location.

InPMps are vital tools for the movement of people, goods and services, information and energy from the source . Due to their transformational nature, they support the policies of distance elimination by closing the gaps of space and offer a positive and distinct impact on the environment. Several InPMps have facilitated the remarkable changes in the global advancement of cities, environmental sustainability, power transmission, interconnectivity and success in the complexities of mega-multi-cities. The development of InPMps are the preconditions for industrialization and economic growth. In recent times, the demand, charter and development of InPMps have risen due to the growing global population, these initiatives are valid responses to the increasing populace. The world bank noted that InPMps enhances the activities of the agricultural and manufacturing sectors, and InPMps investments also support lives and aid poverty eradication. According to New Economic Geography literature (Krugman, 1991; Holtz-Eakin & Lovely, 1996), InPMps such as seaports and airports promotes market integration and helps to raise domestic and international trade. Similarly, Reinnika and Svenson (2002), forwarded that the successful InPMps such as power generating facilities and reliable transportation network have positive effects on private and foreign direct investments (FDI) while the poor nature of these structures have detrimental effects on the private and foreign investments. In support of this idea, (Calderon & Serven, 2014:5), noted that InPMps support the factors of production that contributes to economic growth; power aids production, educational facilities support human knowledge leading to a heathier living, and oil and gas structures strengthens the energy sectors.

An effective transportation network such as tunnels, highways and trains decrease the travel time by more than 40% (Wael and Chandra 2014) which ultimately improves workforce production time. InPMps also serve as the backbone for a rapid delivery of products and services. Ferreira, 1999 and Agenor & Neanidis, 2006 posits that the availability of a reliable telecommunication facility enhances more communication and eliminates time wastage among managers and workers. The inclusion of sustainable InPMps into the construction industry did not only prove that green infrastructure manages only stormwater, but it also provides other social, economic and environmental benefits not supplied by the gray infrastructure. Green InPMps have lesser project cost, consumes much more lower utilities (water, electricity and gas) and have higher return on investments (EPA, 2017). At the household level, green InPMps prevents health issues and promotes healthy food, it also reduces unemployment and maintains economic stability at the community level (EPA, 2017).

**1.1 BACKGROUND AND NEED**

Virginia and Elliott (2019) noted that an underground InPMps such as the Boston Big dig was a solution to an initial physical effect of transportation within the Boston Metropolis. Its construction reduced the travel time within Boston from 19.5 minutes to 2.8minutes and an increased 800,000 commuters from Eastern Massachusetts to Logan airport (Mac 2006). The operations of the Channel-Tunnel infrastructure largely increased the capacity of cross-transportation between France and Britain by 62% (Peter and Daniel 2013). Similarly, the main benefit of the Panama Canal to the global trade was the reduced travel time of shipping vessels (Noel and Carlos, 2008). The Canal aided the trade between the United States, South America and Europe (Table 1.0)

Table

Description automatically generatedTable 1.0; Representative Distances (miles) Source: www.distances.com.

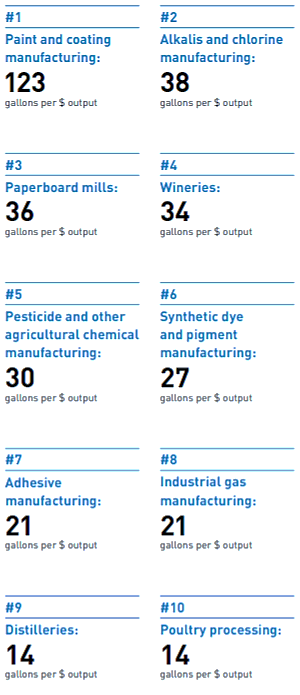
In 2011 and 2012, about 1.4 million people were present at the art performance event at the Sydney Opera house. This architectural masterpiece has consistently maintained the main reason for the substantial number of tourists that visits Sydney. In addition, (Deloitte 2013) observed that about $558 million is being generated annually due to this visit, the edifice sustains its GDP of about $775 million to the Australian market and supports over 8,400 employees. In the United States, while the healthcare infrastructure and its benefits has increased the GDP from 5% in 1960 to 18% in 2015 (EoC 2017), the US water infrastructure cannot be neglected, and its disruption will affect the food and other industries. The water utilities have also supported other manufacturing sectors of the US economy. (Figure 1.1). Accordingly, the InPMps industry requires about 13,000 residential units to support the global population before 2050 and as a response, the US bureau of Census Board recorded an increased housing unit from 583,000 in 2009 to 1.68 million units in 2021 (US census bureau, 2021)

Figure 1.1: Most water-intensive industrial sectors. Source; The Economic Benefits of Investing in Water Infrastructure (2020)

World bank 2012 remarked that most countries depend on the GDP of the oil and gas Infrastructure for the sustenance of its economy. The income from the oil and gas infrastructure is a financing tool for other macro sectors and it has being the backbone for energy generation, chemical production, petroleum refining, automobile, and air transport industries. Flyvbjerg (2013) noted that several productive InPMps span across the developed and developing nations, and in his book, Flyvbjerg (2013) pointed out other InPMps that includes:

* *Hong Kong’s Chek Lap Kok airport,*
* *China’s Quilling tunnel,*
* *Akashi Keiko bridge in Japan,*
* *Sydney’s harbor tunnel,*
* *Malaysia’s North–South Expressway,*
* *Thailand’s Second Stage Expressway,*
* *The Sao Paulo–Buenos Aires Superhighway,*
* *Bi-Oceanic highway right across South America from the Atlantic to the Pacific,*
* *the Venezuela–Brazil highway.*

The InPMps environment has witnessed dramatic changes due to globalization and economic growth. The completion and operations of these infrastructure have produced a livable and habitable global environment. Despite their remarkable impact, InPMps are renowned for their cost overrun, schedule slippage, quality issues and safety concerns, and they often fall short of the main project objectives. Construction delays have contributed to the defeats of unaccomplished project ventures and a poor record of timely completion (NEDO, 1983). KPMG 2015, concluded from the survey that project failures in energy and natural resources have risen from 29 to 71 percent, public sector failed projects have risen from 10 to 90 percent, while projects in other fields have also risen 39 to about 61 percent (Figure 1.2). In the same report, a quarter of the surveyed InPMps were completed within 10 percent of the original deadline and one out of ten public projects finished on-time (Figure 1.3). Edward 2011, from a study of 300 global InPMps, concluded that 65 percent of these projects failed to deliver their project goals. Many of these projects failed not only in cost overrun and schedule, but also failed in the delivery of expected products’ quality.

Chart

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Figure 1.2: Underperforming projects in 2014. Source; KPMG International, 2015

Chart, bar chart

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Figure 1.3: Projects that meets planned project cost. Source; KPMG International, 2015

Project delays in InPMps were not due to additional cost or extended schedule only, but in more cases, delays were due to a failure in the expected product. Many completed InPMps might have succeeded technologically but have failed financially. The longest underwater rail connecting United Kingdom and France; the Channel Tunnel was assumed to be financially and economically beneficial, but its capital cost ended 80% higher and it was also financed at 140%. (Anguera, 2006) noted that the British economy would have been better had the Tunnel never been constructed. Similarly, the Boston’s big dig, been praised as one of America’s biggest highway infrastructures (Tobin, 2001), a triumph of postmodern engineering over modernist hubris (Hughes, 1998). This engineering feat has been labelled a costly project that overran its budget, delayed completion and a failure by some standards of project management (Flyvbjerg, 2017).

The Sydney Opera house, despite its contributions to Australia’s GDP had a completion period increased from 4 to 14 years and an escalated cost overrun from $7.2m to $102m, Denver’s $5 billion project was criticized for its 200 % project cost increase and the Hong-Kong’s new $20 billion Chek Lap Kok airport which opened in 1998 had an increased projects cost and a reduced income flow for the airport. These problems of cost and revenue at the airport impacted Honk-Kong’s GDP (Flyvbjerg et al, 2003). The Suez Canal also recorded a project delay of 166%-time extension and a project cost overrun from $1.5m to $100m. The environmental impacts of some InPMps such as the Germany’s high-speed rail was initially neglected until it received criticism from environmental advocates.

**1.2 RESEARCH STATEMENT**

InPMps are important contributors to the advancement of the society and economy, they are equitable elements that strengthens the civil rights, human needs, the growth and sustainability of the environment. Despite the best applicable practices for the development and construction of these expansive and expensive ventures, several difficulties could spur an infrastructure from a detailed planning to a massive failure. Successful megaprojects support the economic growth while their failure can set development backward for years (Merrow, 2011). Spontaneous global urbanization has prompted series of growth surge in the InPMps industry that their failure could result in the collapse of sponsors, firms and the government. Merrow 2011, noted that the proportion of InPMps delivery failure has been put as high as 66% and an increased number of these infrastructures experience both the substantial social and economic shortfalls.

This research examines the significant risk factors largely contributing to the persistent recorded failures in the development of infrastructure projects and megaprojects. The inadequate management of Risks, which is the main failure factor in their entirety cannot be fully eliminated from the development and construction of InPMps, they could be accepted and managed efficiently than they have been previously addressed. Most risks emanating from the development of InPMps have resulted in massive cost overrun, time extension, defects in project quality and safety concerns.

A purposeful deeper approach to risk assessment and management will enhance the delivery and performance of the InPMps. Relative to the issues emanating from the risk management and development of InPMps**, *there is a need to assess the major risk factors in the InPMps, further determine the core behavior of the risk factors within the project lifecycle and their cascading impact on the project constraints****.* The research identifies the failure point of risk factors within the project lifecycle that impedes the development and delivery of the InPMps.

**1.3 RESEARCH OBJECTIVES**

It is crucial to assess and curb the root causes of all failed and failing InPMps, a closer and profound assessment of these risk factors would enable industry professionals a thorough risk management procedures before and during the development of the InPMps. In order to achieve these concepts, the research investigates a backward exploratory analysis of risk factors in the InPMps sectors. The main objectives of the research are to;

1. **Identify the major risk factors associated with Construction Projects and Megaprojects (InPMps)**
2. **Determine the Originating point of risk factors on the project lifecycle.**

* ***An assessment of risk factors originating point on the project lifecycle.***

1. **Determine the Impacting point of the risk factors on the project lifecycle.**

* ***An assessment of the point/area impacted by risk factors on the project lifecycle?***

1. **Determine the cascading impact of risk factor from the project lifecycle and the effect on the project constraints.**

The knowledge of these objectives in the InPMps industry will foster the ideal management of risk factors, cognizance to the occurrence of risk at a certain lifecycle and the overall effect on project success.

**1.4 RESEARCH SCOPE**

This research aims at highlighting the behavior of risk factors within the project lifecycle to the cognizance of industry professionals. It intends to address the relationship and effect of these behaviors on the project’s constraints. This research centers on the assessment of infrastructural InPMps and not industrial InPMps. Infrastructures are the facilities, structures and elements that sustains the humans’ daily activities. They help in realizing a faster economic development and they fuel the small and medium scale companies. However, industrial projects are designed and developed to produce certain goods/products. They make products specifically to be sold and their products also support the existence of the infrastructure projects. Table 1.4 shows the different types of infrastructure and industrial projects. A key benefit of the research is the knowledge for an adequate planning and management of construction risks throughout the construction lifecycle.

To achieve these aims, a part of the research scope focuses on some of the prominent construction risks factors within the InPMps. Several authors and papers have addressed the risks factors that negatively influences the success of InPMps. A few of these numerous papers includes Chan et al. (1997), in the examination and evaluation of the importance index of 83 risks factors responsible for delays in Hong Kong’s construction industry. El Razek et al. (2008) also investigated 32 risks factors which were the main causes of delays in Egypt. In his paper, Shrestha, (2018) investigated 30 risks factors that causes delays in US construction projects. Within Turkey’s construction sector, 34 risks factors were examined by Kazaz et al. (2012), to have affected project duration within the country. One of the scopes of this research addresses the risk factors examined by Hastak and Shaked (2000). The paper presented and identified potential 73 risk factors that influence projects at either macro, market or project level in an international construction operation. In their paper, they highlighted and ranked the 73 risks factors affecting the macro, market and project level. 32 risks factors were referenced from this paper based on the criteria and sub criteria used to establish the interrelationship and hierarchy between the various risk factors at the macro, market, and project levels.



Table 1.4: Infrastructure and Industrial Projects

Within the research scope is also the examination of the behavior and interrelationship that exist between risks factors and project lifecycle. The development of InPMps navigates across the phases of a project’s lifecycle which includes Inception, Planning, Execution, Closeout, Operation and Maintenance, and Demolition. The research is limited to the assessment of the risks factors within the execution phase of the project lifecycle as illustrated in Figure 1.4. Part of the project management processes for the successful completion of InPMps are the guidance and assistance provided by several existing research for the academic and construction industry to significantly aid the development and completion of InPMps. The research scope will close the gaps of the non-existing research on the assessment of project risks and their performance within the project lifecycle.

Ineffective management of risk has resulted in the significant wastage in project cost and time, and it has been the leading cause of the persistent failure in the delivery of quality project scope and safety issues in InPMps. These impacts emanate from the incomplete analysis of risks that occurs within some of the project’s lifecycle. The scope of the research also centers on how overlooked risks within the project’s lifecycle affects the projects metrics. Investigating this scope area will present the correlation of risks from a projects lifecycle that affects any of the project’s constraints such as cost, schedule, quality and safety. The assessment of risks factors and their impacts on the lifecycle and metrics of projects are considered in all sizes of infrastructural development having a cost range of below and above Diagram

Description automatically generateda billion dollar.

Figure 1.4: Phases of Project Lifecycle

**1.5 RESEARCH METHODOLOGY**

The research adopted firstly the systematic literature review of existing and identified risks factors as shown in Figure 1.5. The literature review process involves critically reviewing and evaluating the data and results of a primary study within the similar research scope. In this research, it was important to create the list of risks factors to be examined and the systematic literature review aided this process. The research referenced existing literatures and publications that previously considered 40+ risks factors and the compilation of these references presented a compendium of similar risks factors, with repetition and different choice of words. A cross-referencing of the risks factors in these literatures and the summary, resulted in the 40 risks that were considered in this research.

A high number of risks were simplified to the 32 risks based on repetitions in each literature, relative ranking and risk criteria such as planning, design, construction, financial, operation and technological risks factors. Majority of the identified risks from the previous literatures contained similar risks, and these were grouped to form a single risk factor. An instance is the scope change, change order, scope creep, revised scope, and interference by

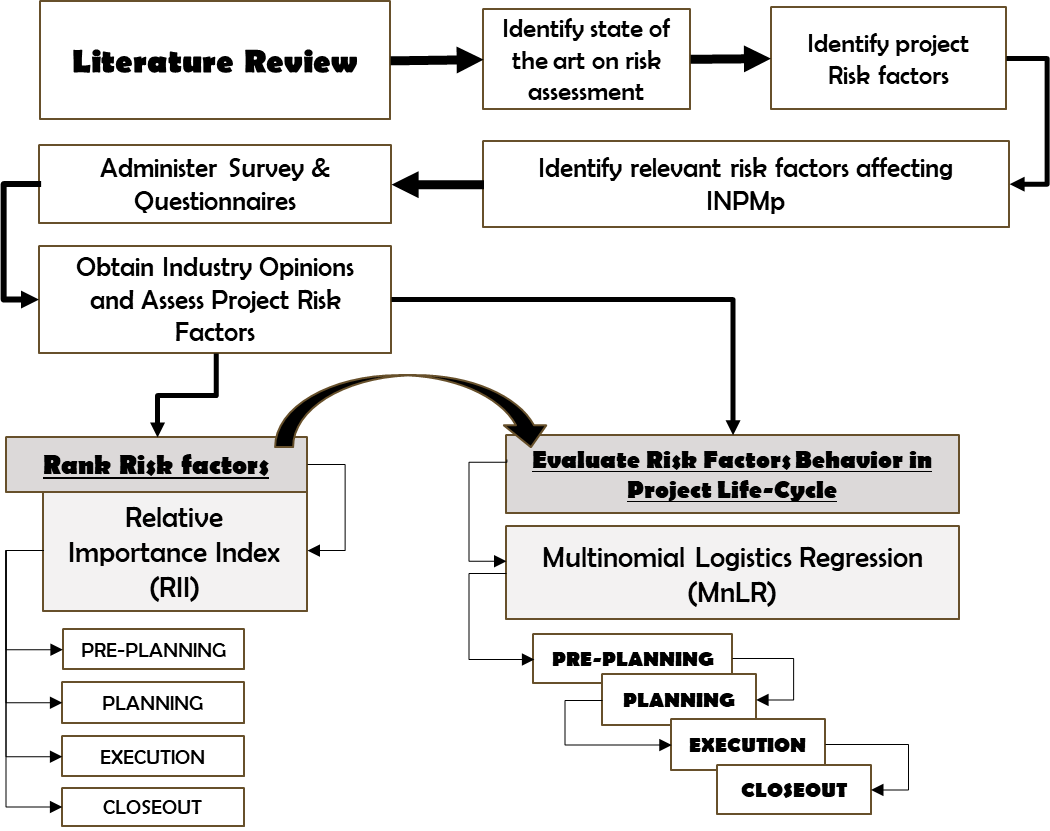


Figure 1.5 Research Methodology

owner were grouped as a single name; Change orders. Lack of proper coordination of project team, mishandling of materials and equipment, and mismanagement of project funds were grouped as the work experience of construction/project Manager. Similarly, errors in contract documents, legal disputes between designer and the owner, and discrepancies in contracts were grouped as types of construction contract and contractual disputes while design errors, inadequate experience of designer and incomplete project scope were grouped as defective design and lack of detailed drawings/documents.

A survey questionnaire was designed and sent to professionals in the project and megaprojects industry. The participants in the survey were requested to rank the identified risks factors according to the point of risk origination and the point of risk impact the projects’ lifecycle. The Relative importance index RII method was employed for this ranking. Hossen et al. (2015) defined the RII as a statistical tool used to determine the ranking of different variable factors. Aside from the RII being the mean of a factor that gives the weightage of respondents’ perceptions, it represents the magnitude to which a variable contributes to the predictive analysis of a result. This research tool has been of value analysis in academics and organizational research and its usage in these sectors have been an accepted method in conveying the important indices of variables.

The RII method has been widely used by several authors in the statistical ranking of variables and mean weightages. A few of these authors includes Kometa et al. (1994), they used the RII method to determine the relative importance of the attributes of clients’ organization which may influence project engineer’s performance. Chan et al. (1997) employed the RII method to rank the potential delay factors in Hong Kong construction projects, the RII method was also used by Hastak and Shaked (2000) to rank the 73 risk factors to be considered in an international construction operation. Gunduz et al. (2013) quantified the delay factors for construction projects in Turkey using the RII and Mukhtar et al. (2020) referenced the RII method to prioritize 51 risks factors and develop a risk map for oil and gas construction projects. The use of the RII tool in this research presented the importance index of ranking the observed 32 risks factors in relative to the originating point at the inception, planning, execution or closeout phase. In addition, the RII defines the ranking of the 40 risks factors in relative to the impact point at the inception, planning, execution or closeout phase.

The cascading effect of risks factors from the originating and impact points on the project constraints (cost, schedule, quality and safety) were determined using the Multinomial Logistics Regression. The Multinomial Logistics Regression (MnLR) is employed as a base classifier where the response variable comprises of more than one category. MnLR evaluates the nominal variable individually in the exclusive subcategory of the dataset, and it predicts response on the basis of categorical or continuous variables to assess the variance within each calculation. In a multinomial logistics regression, the model compares more than a contrast, the log odds of two or more likelihoods analyzed simultaneously (Garson 2009). In general, the multinomial logistic regression (MnLR) model is the result of the binary model, and they both depend mainly on logit regression or analysis. Logit models are applied to data analysis where the response variable has more than one and there are not natural ordering of the predictor categories.

**1.6 RESEARCH OUTCOME**

This research will present the probable causes of delays in projects and megaprojects that could occur within the project’s lifecycle. It will describe the impact of these occurrence on any of the phases within the lifecycle and the final effect on the project constraints. It will also highlight that the neglected risks factors in the early phase of projects development could hinder the success of other project phases.

An initial outcome of the research is the identification of risk factors and their prioritization relative to origination and impact in the life cycle. This outcome will notify construction professionals of possible project delays from such risks if they are not adequately managed. This knowledge will enhance the identification possible risks in some of the phase(s) of the lifecycle and enable prompt decisions be made to avoid delays and other costly consequences.

The research will also present the correlation of risk origination and impact relative to the different types of projects and megaprojects. This outcome will present an analysis of varying risk factors that originates and impacts at a project phase depending on the type of project/megaproject.

The third outcome of the research will be the assessment of the leading causes of failure in the project constraints. These causes will be traced to the impacting factors from to the origination.

**1.7 THESIS ORGANIZATION**

To be provided after other Chapters have been forwarded.

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**CHAPTER 2**

**2.0 LITERATURE REVIEW**

The development of infrastructures remains part of the key component of an economy, its a source of employment, and the model for sustenance. They form part of a remarkably coherent story (Flyvbjerg, B. 2013), and much of which are continuously being proposed and built. More InPMps have been mostly developed in the first decade of the 20th century than any other period and the survival of the society would have been impossible without the existence of infrastructures. In Spite of this development, it’s obvious how many of the InPMps have failed and/or recorded remarkably poor execution. These failures are indicative of the level of assessment and management of risk, they also present an understanding of the steps taken that has resulted in project failure. Several causes of project failures are results of the many ignored risks management processes.

Evaluating risks factors and their consequences within the project’s lifecycle, and the subsequent interaction with project constraints is a neglected aspect of the risk management processes. Risks behavior within the project lifecycle and their impact on project constraints are crucial components required for a shift in paradigm in the management of project risks in InPMps. This chapter aptly discusses the multiple existing narratives on these risks components. The narratives includes: risk factors and issues in the project and megaproject industry, risk categorization and risks factors, risk management (assessment and analysis framework), project and megaprojects risk factors (existing narratives on risk factors and establishing the risk factors), project lifecycle phases (preplanning and feasibility study phase, planning, design and engineering, phase, construction and procurement phase, close-out and scope validation phase), risk factors and impacts on project metrics (project cost and cost overruns, project schedule and schedule extension, project quality, project safety),

**2.1 RISK FACTORS AND ISSUES IN THE INFRASTRUCTURE INDUSTRY**

The InPMps industry is a complex entity that is constantly being met with challenges. Its success is highly dependent on the compliance to the building regulations, laws and codes, management of labor, materials and equipment, and the integration of team members and stakeholders. In spite of these compliance, the uniqueness of the construction industry with its inherent set of issues and advances rarely presents and optimized construction lifecycle. These have been a major driver to risks originating within the construction industry. Risk and the construction industry are an almost inseparable entities, that the union has birthed several concerns leading to research in both the academic and construction sectors. Each research had sought after an improved approach for the assessment and management of risks factors within the industry. The development of InPMps and a critical examination of likely risks factors promises an almost hitch-free project implementation, but a misinformed, an inadequate feasibility study, and a lack of detailed planning produces a disrupted project deliverable. This results in projects that are extremely risky, and the risks are being concealed from the stakeholders Flyvbjerg (2013).

The definition of risk spans various authors and perspective: Simon, Hillson and Newland, 1997 defined risk as an event or set of circumstances that, should it occur, will affect the achievement of a project's objectives. Risk was also defined by Kartam (2001), as the probability of occurrence of some uncertain, unpredictable and even undesirable events that would change the prospects of investment, while PMI (2013) defined risk as the uncertain event or condition that its’s occurrence could cause a positive or negative effect on one or more project objectives. Similarly, construction risks are sets of uncertain occurrences, if not thoughtfully managed are bound to disrupt project implementation and deliverables. They are threats to project deliverables and are the likely contributing factors leading to the failures in InPMps’s objectives. While the projects industry is associated with a reduced but unavoidable risks issues, the megaprojects sector produces major numbers of uncertainties capable of disrupting the economic goals of a nation. These uncertainties impact project constraints such as cost, schedule, product quality, and safety.

Infrastructures support the development of the environment, cities, and individual livings. They can be environmentally, economically, and socially transformative and over the years, an increased number of these projects and megaprojects have failed around the world. (Delisle and Olson, 2004) cited the growing incidents of project failure, (Mladen, R. 2015) established belief that megaprojects are not difficult but often unsuccessful and Brooks 2015 corroborated that InPMps are united by their extreme complexity and by a long record of poor delivery. Merrow 2011, noted that the success of the InPMps can spur economic growth, while their failure can set a nations’ development backward for years. Despite some of the unpleasant records, the development of InPMps are still on the increase and filling up gaps in the construction industry. Developers are still able to convince financiers for the successful execution of the mega-infrastructures, they promote their concept and convince their clients to initiate such mega-structures (Flyvbjerg et al., 2003). It is pertinent to note that sustaining infrastructure projects and megaprojects is essential, life-saving and places a demand to protect the environment.

Development and execution failures have consistently dominated the InPMps notwithstanding the flawless design and planning processes. In fact, these failures, recorded from several projects and megaproject are associated with a poorly managed risks factors and a weak project management technique. InPMps could be challenging, and the evaluated number of failures in megaprojects delivery have been in the range of 66%. Merrow 2011, explained that some of the core issues encountered in the development of megaprojects are attributed to cost increase, project budgeting, feeble planning, incorrect means and methods and the impact from uncertainties. World Bank (1994) reported that more than 1000 projects had an 80 percent quality delivered at the appropriate completion time due to the extent of the front-end planning while projects that were implemented with an insufficient front-end phase showed a success rate of 35 per cent. Flyvbjerg (2014), consequently reported that the continuous under-performance in infrastructure development is strictly poor and has not improved for the 70-year period for which it has been measured in terms of the project metrics.

The Sydney opera house, currently one of the major contributors to Sydney’s economy initially had a 4-year execution plan with a project cost of AU $7.2 million but recorded a completion cost of AU $ 102 million- and 14-years period to completion. These failures were results of the mismanagement, negligence of risks, uncertainties associated with an improper management process, scope changes, resource planning, cost management, and non-compliance to project specifications. The Boston Big Dig is famous in the history of failed infrastructure in the United States. It is the largest, most complicated, and technically challenging highway construction project in American history. The project had an original 16-year construction schedule (from 1982 to 1998) with a proposed cost of US $2.6 billion. Construction was finally completed in 2007 with the cost increased to US $14.8 billion and a final actual estimate of US $24 billion was released in 2012 by the Massachusetts department of transportation. The excess time and additional cost of this magnanimous project were results of contempt to the risks factors which included bureaucratic delays, delayed design and regulatory approvals, poor feasibility study of underground utilities, constant change in work scope, unrealistic project schedule, etc.

A few other risks factor such as lack of proper construction equipment, stakeholders’ disagreement and influence, weather conditions and other natural factors largely contributed to the failure in the Suez Canal project. This man-made mega-waterway infrastructure that connects the Mediterranean Sea to the Indian ocean through the Red Sea recorded a 166%-time extension from 6 years at the cost of US $1.5 million to 10 years at a final cost of US $100 million. Flyvbjerg et al, (2003), indicated that the channel tunnel, opened in 1994 at the construction cost of €4.7 billion, with several near bankruptcies caused by construction cost overruns of 80%, and a 140% financing costs higher than the forecast and revenues. The inexperience contractor, ignorance to construction means and methods, political and institutional instability, stakeholder’s disagreement and incessant change in project scope contributed to the failure of the channel tunnel.

In addition to the few reasons noted above, the inappropriate assessment and management of risks factors have contributed to the major failures in the InPMp industry. Often, these projects fall out of the control of the project team except a thorough risks management methods are developed and applied throughout the phases and lifecycle of the project and megaproject. The risk assessment and management methods stated by (Burke, 2003), usually comprises identification, analysis and response.

**2.2 RISKS MANAGEMENT AND THE CONSTRUCTION INDUSTRY.**

Infrastructure projects and megaprojects InPMp, due to their construction methodologies, are characterized by high level of uncertainties. They are highly-risk prone and are prone to planning, construction, resources, political and financial risks. These uncertainties have impacted the project performance measures thereby resulting in cost overrun, time extension, failed project quality and an overall unsuccessful project objective. The vulnerability of the construction industry due to its business processes and the environment it operates, and the influence from risks generates a cascading effect on the stakeholders, environment and the economy. Although it remains a challenge and seemingly almost impossible process, but the effective management of risks factors on infrastructure projects and megaprojects limits the impact of risks on construction project. Risks factors can be evaluated during project execution, but they will persistently affect project objectives such as cost, time, quality and safety if not accurately assessed. Flanagan and Norman, 1993; Akintoye and MacLeod, 1997; Smith, 2003 asserted that due to some distinctive construction features, such as finance, environment, and the management processes, the infrastructure projects and megaprojects (InPMps) are subjective to risk influence.

The process of identifying risks, performing a qualitative and quantitative assessment, and determining the appropriate risks response, monitoring and control measures is termed risks management. Uher 2003, defined risk management as a tool that aims at identifying sources of risk and uncertainty, determining their impact, and developing appropriate management responses. The National Institute of Standard and Technology 2002, also defined it as a process of identifying, assessing, and taking the steps to reduce its impacts to an acceptable level. Risks management plans determines the structure and process of the risk management process. Douglas 2009 stated that risks management entails identifying, assessing, prioritizing, applying managerial efforts to minimize the impact of unforeseen events for the realization of project objectives. Elements of risks management are planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning, risk monitoring and control (Dey, 2012; PMI (Project Management Institute), 2008).

Risks Management is a determining factor that supports the success of infrastructure projects and megaprojects. Adequately managing risk reduces the issues emanating from the risks impacts, it supports the achievement of project goals and also strengthens the reputation of the construction industry. In project planning, risk management is an important consideration in cost-benefit analysis, production cost, schedule and financial variables (de Palma, Picard, & Andrieu, 2012). InPMps are inherent of several risks factors resulting in delays and failures in their lifecycle (Flyvbjerg, Bruzelius & Rothengatter, 2003), it is therefore important to utilize the systems of managing these risks effectively prior to execution. More importantly, it is beneficial to lessen the likelihood of risk occurrences in InPMps by employing processes for mitigating risk impacts. Planning and development of InPMp is a tedious and ambiguous task, making it more crucial for stakeholders to emphasize on the successful management of risks.

An effective Risk Management practice must recognize the various risk factors embedded within the project’s lifecycle. It must enable adequate risk control and also present the overall project risk exposure. In infrastructure projects and megaprojects, the appropriate method of risk management is during the pre-project or concept phase, when the scope and objectives of the project are being clarified and agreed Hillson (2014). At this stage, project objectives along with the risks are discussed extensively and are implicitly managed through the decisions made on scope, structure, content and project context Hillson (2014). Subsequently, the traditional explicit method of risk management can be utilized in the project execution. The two levels of risk management as shown in figure 2.0 in infrastructure projects and megaprojects includes;

* Implicit risk management focuses on the entire InPMp risks through decisions made about the structure, scope, content, and context of the project Hillson (2014). This management process is executed during the pre-planning and planning stage of the project.
* Explicit risk management addresses specific project InPMp risks using the traditional method of identification, analysis, response, and control, usually during the execution and the rest of project lifecycle.

Diagram

Description automatically generated

Figure 2.0 Implicit and Explicit Risk Management Processes

Risks occurrence within the construction industry are not always complemented with negative results, proper identification and management could result in early detection, construction profits, market expansion and enhanced stakeholder engagement. The Assessment and evaluation of construction risks could be a tedious process, but with a detailed identification and analysis, disasters emanating from risk could be reduced or eliminated.

**2.2 RISKS CATEGORIZATION AND RISKS FACTORS**

An increasing number of studies have presented various risk factors within the infrastructure and construction projects and Megaprojects. The challenges and ever-changing construction environment produce uncertainties and risk within the industry. These risks can be categorized and factored into different segments. From his research, P.J Edwards (1998) classified risks factors into two categories: natural and human risk factors. He described that natural risk emanates outside the human procedure and the human risk which included social, political, economic, financial, legal, health, managerial, technical and cultural risks fall within the human systems. Pejman Rezakhani (2012) classified project risks into external, operational, project management, engineering and financial. Patel Kinnaresh (2013) justified some of these assertions in his research and concluded that financial, construction and quality risks were associated with construction failures.

Risks classification has been utilized based on the sources: construction management, external influence, technical capability and corporate related (Project Management Institute, Practice Guide for Risk Management, 2013). Rezakhani (2012) corroborated this by grouping risks into operational, external and internal, project management, engineering and finance related risks. Eaton (2013) also used the SLEEPT acronym for risks classification into Social, Economic,E, political, and Technological. Adu and Anjiba, 2015; Luka and Ibrahim, 2015 also grouped construction risks into Management, design, financial and economic, material, labor and equipment, while Zeng et al. (2007) adopted resource-related risks classifications such as human, site material and equipment risks. Risk categorization which included project finance, team managerial ability, technical and construction issues, stakeholder partnering, environmental and force majeure, legal and economy were explained in the recent study by Alashwal and Al-Shabahi, (2018) and four of these categories: construction, physical, estimators and financial were validated by Eliufoo (2018). Oyedele (2015) did a review of the risk management and its categories in the Nigerian construction industry and identified thirteen risk categories: economic, legal, political, security, government policy, year of the project, detail of brief, corruption, time, location, project complexity, management experience, and project sector. Figure 2.1 shows the comparison between risk Categorization and risk factors.

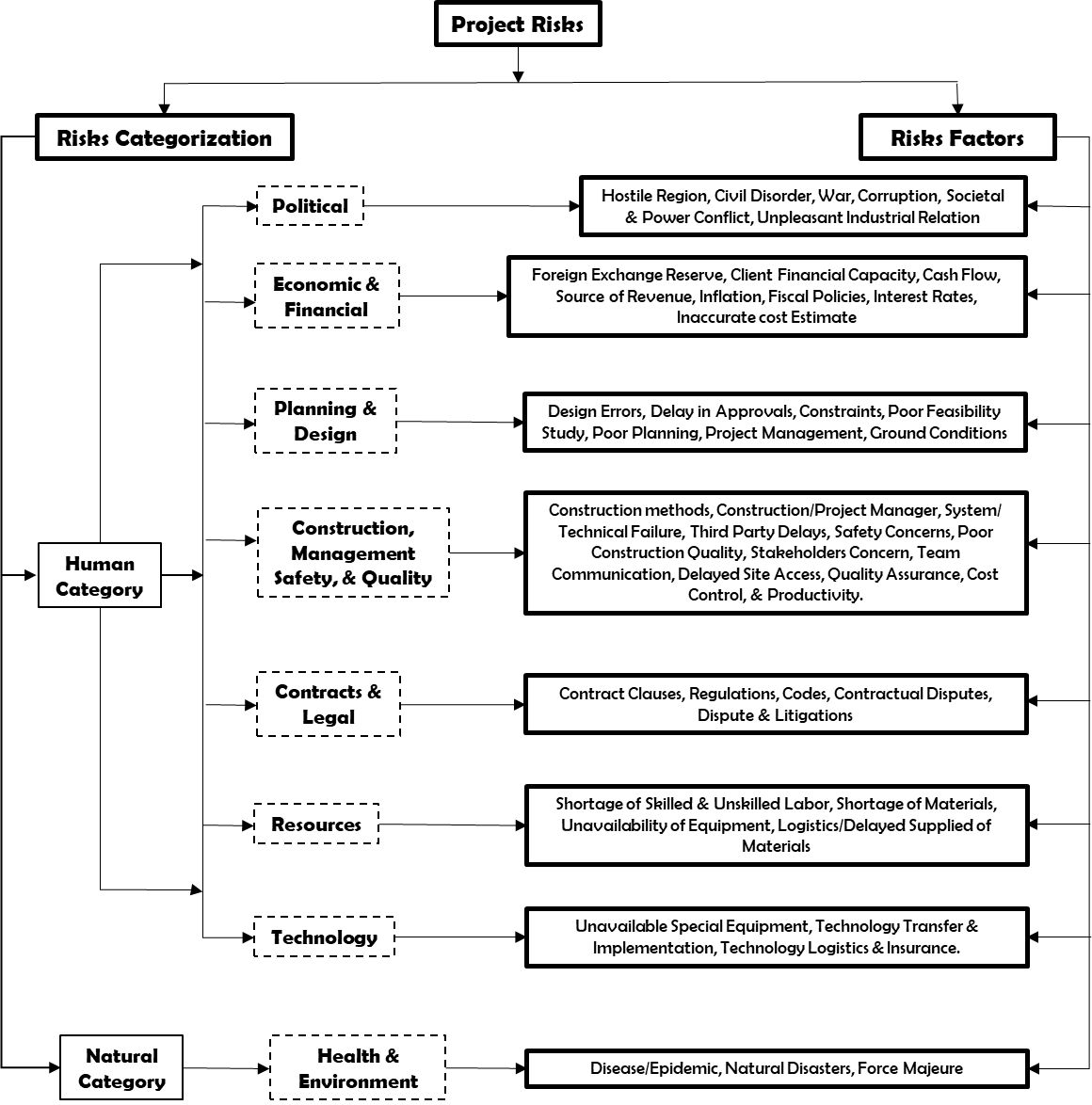


Figure 2.1 Risk Categorization and Risk Factors.

In this context, the above risk classifications were further categorized into risks factors.

**Political Risks:** Ashley & Bonner (1987) explained that the interference of government with construction operations are forms of political risks. Howell and Chaddick (1994), describes political risks as those social events that are likely to influence construction environment and international expansion. (Mortanges and Allers, 1996), also explains that political risks relate to the political activities, government intervention within (Zhuang et al., 1998) that endangers construction success. Ling and Hoi, (2006) stated that political risks are difficult to mitigate due to their unpredictability nature and studies on these risks factors have revealed their identification and management relative to foreign direct investments and international joint ventures. The political unrest may not influence the construction business, but may impact the construction market Hastak, M. and Shaked, A. (2000).

**Economic & Financial Risks:** these are economic and financial uncertainties that do not support construction success. These risks are likely to emanate from economic and financial crises such as underdevelopment, exchange rate, reserves, inflations and fluctuating prices of construction materials. Other uncertainties that might affect construction operations are high interest rates, inaccurate project estimate. Stakeholder capacity to finance the project. De Neufville et al. (1977) recommended a contract model that considers the condition of the economy and Warszawski (1981) also advised the inflation status to be considered during project cost estimates. A dynamic laws and regulations, safety rules, insecurity, civil disorder, and communication barriers are forms of economic and financial risks.

**Planning & Design Risks:** These risks are associated with the feasibility studies, pre-planning and planning stages of the construction process. Some of these uncertainties are due to unclear project scope and specifications, and vague design details. Planning and design risks causes delays to schedule resulting from unforeseen ground conditions, inefficient team communication, and coordination with the locals. McManus et al (1996) evaluated risks in architectural projects and concluded that delays in the planning and design phase included inadequate schedule control by the engineers, inaccurate scope review, ineffective project planning and coordination.

**Construction Management, Safety, & Quality Risks:**  These are usually the most significant risk in associated with the projects and megaprojects Cost overruns, time extensions, lack of proper coordination, and accident are classified under these types of risks. The Incompetence on the part of the construction/project manager possess a threat to the construction project, and if not adequately evaluated will further cascade more damages to the project. These risks factors are associated with project execution, materials logistics, engineering and procurement processes. Hastak, M. and Shaked, A. (2000) also noted that bad quality of material and bad completed works is associated with construction and quality risks. Construction risks are often associated with incomplete design, change of scope, insufficient resources, inadequate specifications, scarce construction materials, productivity of labor, equipment and site conditions, quality standards.

**Contracts & Legal Risks:**  Most legal and contract risks that affects construction projects are inadequate legal framework that imposes legal ruling, inadequate joint venture contract terms, and lack of well-defined codes and building laws. Zhuang et al. (1998), stated that regular changes to rules and regulations governing a regions construction process present uncertainties to the construction industry. Shen et al. (2001) concluded that increase in construction materials is a result of legal and contractual policy changes.

**Resources & Technology Risks:** Unavailable skilled and skilled workers are likely to affect the schedule and cost of a project. In addition, scarce construction equipment, delayed construction materials, unavailability of required technology for construction processes are risks associated the resources and technology.

**Health & Environment Risks:** Construction site are prone to outbreaks of disease and infections, and the event and effect of epidemic is a major set-back for project success. Another set of health and environment risks are natural disasters such as flood, hurricane, tornado and earthquake.

**2.3 PROJECT RISKS MANAGEMENT FRAMEWORK**

Risk Management is the methodical process of identifying, assessing and responding to project risk. InPMps are inherent of several risk factors that causes delays or failures to construction during the project life cycle (Flyvbjerg, Bruzelius & Rothengatter, 2003), and the risks management processes are crucial to addressing these. The introduction of a risk management plan addresses the impacts of risks on projects and megaprojects. Risks management processes have been of a greater relevance to the InPMPs, it is a conceptualized method of assessing and managing risks. Although several other methods have been made, the risks management still represent the foundation of managing a successful project in the InPMps industry. Every stage within these processes should be included to address the risks and adequately employ all phases of the project.

High risk impact and their significant effects are defining properties of InPMps, hence, an effective risk management is imperative for the development and a benefit to the industry. The risk management method is not a recent development only in the construction industry, but it has been applied in facets requiring an analyses, assessment and decision from a risky condition with essentially uncertain results. However, its implementation as an acceptable analytical procedure that has been applied to the management of InPMps issues and it has been a recognized tool for appropriate decision making. It examines the integration of risky policies, the formation of risk cognizance, and through risk management, clarity increases, project issues can be lessened from the outset by been proactive and projects are properly planned for execution. By this method, impacts and consequences are mitigated and the project manager holds the full control over the project.

Managing risks in InPMps has gathered international recognition due to the numerous and extensively conducted research. Despite this, the risk management methodology requires more attention and derivative benefits to the construction industry. Project scope and products are unique to individual projects, as such, the risk management methodology should address only the scope and complexity of the individual projects. Conducting a risk management process for the InPMps could be quite challenging and two types of risk management procedures have been considered while managing risks on InPMps. The preventive techniques allows the management of risks before the project starts, it assesses the predicted risks factors during the construction and closeout of the project, while the remedial techniques evaluates the impacts of a risk after it has occurred. Risks initiates from various sources and impacts phases of the InPMps at various time. These risks and their causes should be drawn along with the respective impacts, and the planned accordingly for according rectification. Risk management does not measure the success of a project, but it is a process that enhances the success of InPMps; hence a proactive and not a reactive tool. Risk management acknowledges the concept of uncertainties such as opportunities and threats in an InPMp development. It formally addresses risks and it is indistinguishable from an overall project management perspective. A key benefit of risk management also involves its aim at dealing with available ambiguities within the project’s life cycle. The objective is to achieve a proper balance between the risks, but not accepting a risk over the other. Risk management includes the assessment framework of identifying, assessing risks possibilities and impacts, planning for strategies, assessing their state, and maintaining an awareness of threats to project success.

Risks management entails stabilizing the various project risks concerns, impact on metrics and the overall wellness of the project. It reflects on various alternatives, assess their strength and weakness and makes best favorable decision for the project. Risk management should be a properly established procedure with an available data and a clear purpose of use. Probabilistic and statistical methods have been employed to provide effective support and decision for managing risk occurrences and impacts on InPMps. However, the decisions on risk factors are to an escalating amount, due to the characterized events of uncertainties and emergence. The uncertain events requires different types of methodologies and this has been a challenge to the risk field to develop suitable frameworks and tools for this purpose ([SRA, 2015b](https://www.sciencedirect.com/science/article/pii/S0377221715011479" \l "bib0131)). The risk management framework comprises of risk Identification, assessment and Risk assessments are employed should be made of each risk's potential impacts to planned capabilities, and whether they have collateral effects on dependent capabilities or technologies.

**2.3.1 RISK IDENTIFICATION**

Gray and Larson (2011)  defined risk as the possibility that an unwanted occurrence will occur, as well as the impacts from known scenarios. However, project risks are not easily assessed because the rate of occurrence and their impact are not usually easily quantifiable. As a result, project risk may be assessed and quantified approximately through statistical means and must be itemized hierarchically for a complete identification and assessment. Risks identification begins with the detailed knowledge of the project’s requirements and objectives prior to the identification processes. And it is crucial to identify a large range of risk factors, as a left-out risk factor might emanate along the project lifecycle. The result of a comprehensive risk identification is checklist. Chapman (2001) highlighted some methods for identifying project risks and uncertainty of events during project execution. These methods include Brainstorming, Delphi Technique, Checklist, Expert Opinions/Structure Interview, and historical data

* **Brainstorming (BS)**: In a risk identification process, brainstorming is an ideal technique for generating ideas and assumptions of likely and unlikely events. It entails a group been led by a facilitator, seeking suggestions and mapping the possibilities of risks factor occurrences. BS as a technique, promotes the creativity of solving problem by sharing ideas and thought process among the participating groups (Gogus, 2012). Brainstorming has been employed extensively in the identification and itemization of likely project risks, and it has been expanded to other areas of management for opinions, explanations and solutions. During the BS session, participants ability for generating ideas are quantified based on the uniqueness of opinions ([Fu et al., 2015](https://www.sciencedirect.com/science/article/pii/S1871187117302729#bib0120)), and these quantification is assessed relative to the solutions delivered by the group or participants. The distinctiveness of ideas, is evaluated estimated based on the dimensions related to novelty, workability, relevance, and specificity of ideas ([Hong & Chiu, 2016](https://www.sciencedirect.com/science/article/pii/S1871187117302729#bib0160)).
* **Delphi Technique (DT):** More than a traditional tool, the DT method has been embraced for uses beyond predictive purposes, becoming widely used as a tool to aid decision making by gathering expert opinion (Gupta and Clarke 1994;  Rowe and Wright 1999; Landeta 2006) This technique is quite similar to brainstorming session, but the participants in this risk identification process are not co-located and they do not know each other. In a consensus where opinions from experts in different locations are gathered to determine prioritization and predict trends/patterns, the Delphi technique is best employed. The DT method is iterative, often with participants expressing their thoughts and opinions severally about certain philosophy or assertions of a project risk in Likert Scale survey procedure. Experts within the construction industry are selected to participate in the DT process and an amount of knowledge in the construction sector is presupposed with these experts. The several rounds of assessing the views and thought of participants presents a further understanding of risk identification in risk management.
* **Checklists (CL):** These are common methods in the management of risks in the construction sector [Pinto et al. (2011)](https://www.sciencedirect.com/science/article/pii/S092575351731559X#b0190). They are simple but very useful predetermined lists of factors that are possible for the project. The checklist containing the list of managed risk from a past project and the response methods to those risks improves the appropriate method of identifying similar risks in the current proposed project. This tool enables the creation of features of risks factors presumed to occur, and it is also used as a control tool prior to risk evaluation and decision making in Infrastructure project. Checklists are highly effective procedure by which the accuracy and efficiency of risk identification depends on and a list of solutions are drawn along with the identified risks during the risk identification.
* **Expert Opinion/Structured Interview**: Project team members with an expertise within the construction industry can be engaged in an interview or opinion session for risk identification. These methods of risk identification reduce the assessment time, and provides an informative list of likely risks that might occur on a similar project previous involved in. All project team members or stakeholders relevant to the project can be interviewed during the risk identification process.
* **Historical Data:** History and the analogy of risk occurrence and its management from past projects can be adopted during the identification of risk on another similar project. These methods have been utilized for risk identification and assessment to predict the present state and potential future impact of risk on projects. Employing historical data to risk identification helps to define how a project metric might behave when such risk finally occurs on the project. It also identifies the risk requiring more attention and that worth accepting and mitigating. Experts should interpret the data and apply the appropriate perspective of risk management as a crucial step while using historical data.

**2.3.2 RISK ASSESSMENT FRAMEWORK**

The intent of a risk assessment is to assess and quantify the impact of identified risks on a project. It evaluates and measures the probabilities of a risk occurrence and its probable level of impacts if they occur. Risks assessment enables the project team to decide which risk or project phase need an additional resource to lessen the impact from risks. The assessment process provides a crucial decision in the development of InPMps, it also presents details of points in the lifecycle of the project requiring more resources to manage or mitigate the probability of effect. In order to successfully manage the assessment of risks on construction projects, Shen et al (2001) established a risk significant index, some of these risk indexes were also identified by Wang and Liu (2011) as ‘low, medium and high’. These represented the level of risk impact as low, medium and high risks. KAU 2010, also recognized a significant index used to quantify the ranking of the risk factors and the ranking of the effects related to these risk factors.

Studies have investigated risk assessment in the construction industry, and each research with its viewpoints. (El-Sayegh, 2008) investigated the risk assessment on the economy and impact relative to Inflation and sudden changes in prices, sociopolitical risk assessment by (Ling and Hoi, 2006), business risk assessment (Wang et al., 2008; Deng et al., 2014), and occupational risk assessment by Pinto et al., 2011. These studies presented the significant understandings of the macro-level risk assessment in the InPMps industry. Analyzing the causes and impact of risk is a significant process in the construction industry, and if not adequately assessed, it could result in the disruption of project metrics and an unhealthy construction industry. Risk assessment is performed by quantitative and qualitative methods

* + - 1. **Quantitative Risk Assessment (QRA):** This is a systematic risk analysis of quantifying risks related to the construction process, it identifies the possible hazards/threats, examines the probable cause and presents the consequences of the risk on a construction project. It answers the questions: what might go wrong, how possible is it to go wrong, and what are the likely impact if the something goes wrong. This is also the process of statistically evaluating the impact of identified risk on the overall project objectives( PMBOK 2011). Quantitative Risk Analysis is performed on already ranked, noting the effect of each ranked risk and assigning numerical rating to the risks. In the QRA, the single impact of the risk factors is not considered, but it analyses the impacts on the overall project. Methods of quantitative risks assessment includes:
* **Sensitivity Analysis**: Sensitivity analysis of risk models identifies the most important risk factors, the effects and priorities the steps for mitigating the risks. This is performed to ascertain the project risk factors likely to have maximum disruption or effect on the delivery of project. [Baker et al. (1999)](https://onlinelibrary.wiley.com/doi/full/10.1111/0272-4332.00039#b5) noted this method as one of the primary risk quantitative tools applied in risk management. In risk assessment, the sensitivity analysis verifies the sensitivity of different risks impacts on project success. [Jones (2000)](https://onlinelibrary.wiley.com/doi/full/10.1111/0272-4332.00039#b68) suggested that sensitivity analysis provides the basis for project planning measures to lessen the impact of project risks, it also helps to assess uncertainties for the purpose of prioritizing additional impacts of risk on project (Cullen and Frey, 1999). Sensitivity analysis as a risk assessment method has been applied in the risk analysis of engineering systems, physics, economics, medicals, and social sciences decision-making process. ([Oh and Yang, 2000](https://onlinelibrary.wiley.com/doi/full/10.1111/0272-4332.00039#b106); [Baniotopoulos, 1991](https://onlinelibrary.wiley.com/doi/full/10.1111/0272-4332.00039" \l "b6); [Helton and Breeding, 1993](https://onlinelibrary.wiley.com/doi/full/10.1111/0272-4332.00039#b57); [Cheng, 1991](https://onlinelibrary.wiley.com/doi/full/10.1111/0272-4332.00039#b23)).
* **Scenario Analysis:** The scenario analysis focuses more on the risk factor with the greatest impacts on project and develops the alternatives for operations and how the likely high risks will influence the success of the operation. This foresight-structured procedure helps the project teams make strategic preferences about where and how to assess the impending risks, its impact and where to direct its mitigation plans. Mulvey and Erkan ([2003](https://onlinelibrary.wiley.com/doi/full/10.1111/j.1539-6975.2012.01506.x#jori1506-bib-0017)) illustrated that when scenario analysis is adequately used, it reveals many important aspects of a risk factor situation that would have been omitted. Scenario analysis for risk assessment must be done within a time frame, otherwise, it will render the analysis obsolete. The Scenario analysis simulates the likely occurrence of all categories of risk based on certain notions (López-Baldovin et al. [2006](https://link.springer.com/article/10.1007/s12145-020-00518-w#ref-CR11)). A scenario-analysis-based risk-assessment methods can intuitively and precisely suggest the extent of the impact from risks and the affected scope, this can accurately present the distribution pattern of the risk impacts.
* **Monte Carlo Simulation:** This method examines the [permutations](https://www.sciencedirect.com/topics/mathematics/permutation) of uncertainties and risk occurrences in a project. Firstly, the appropriate distribution function is determined for each uncertain risk and further analyzed in the second phase of risk assessment process. This method may be applied to project schedules to evaluate probability of completing the project within the target completion date. Project manager and risk experts allocates a probability distribution function of duration to each work task or work packages within the project to achieve an accurate evaluation of the risk assessment. The distribution function entails a three-point estimate of most-likely, worst-case, and best-case scenarios. These estimates are then simulated, and after simulation, project team can report the individual probability of risk impact on the project. [Smith (1994)](https://link.springer.com/article/10.1057/palgrave.rm.8250017#ref-CR28) outlined how Monte Carlo simulation assists managers in choosing from different potential investments and projects, it is also used to understand the behavior of risks on construction projects; [Gilchrist et al (2003)](https://link.springer.com/article/10.1057/palgrave.rm.8250017#ref-CR11) developed a the simulation model that permits contractors to calculate, mitigate the existence, and reduce the impact of construction noise on their projects. This model was tested and validated using field measurements during various stages of the construction of an eight-story parking garage in London, Ontario, Canada

**2.3.2.2 Qualitative Risk Assessment:** Compared to the quantitative risk models where likelihoods of risks are measured quantitatively, the qualitative risk assessment approach utilizes a subjective risk measurement to describe the probability of the risk factors. Qualitative risk assessments present an estimated interpretation of results if little or no data exists, and they are easily understood by the project stakeholders. ([Gravenor and Kao, 2003](https://www.sciencedirect.com/science/article/pii/S0167587711000055" \l "bib0050), [Heim et al., 2006](https://www.sciencedirect.com/science/article/pii/S0167587711000055#bib0060)). Qualitative risk method is a subjective approach of assessing risk, it measures the likelihood of risk occurrence and the level of impact of the risk. The main purpose of this method is to ascertain severity of occurrence and impact and the results are documented in the risk assessment matrix (Figure 2.2) mainly to report potential hazards on the project. Qualitative risk assessment can be analyzed with the following methods:

Chart, table

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Figure 2.2 Risk Assessment Matrix Table. ***Source; https://www.safran.com***

* **Risk probability and impact assessment:** The application of the risk and impact assessment method evaluates the likelihood of occurrence of an uncertainty and its impact. The effect of risk project is measured relative to its positive consequences for opportunities, and the negative effects which result from threats. In risk assessment, probability and impact should be tailored to a single and unique project, this will enable a clear definition of scale of assessment and should be drawn up within the project scope. In the probability and impact assessment matrix, PMI (Project Management Institute) noted the risk probability range from '*very unlikely*' to *'almost certain’*; and the numerical measurement of impact scales from '*very low*' to '*very high*'.
* **Probability/impact risk rating matrix:** The Probability and impact assessment method are base for the quantitative analysis. The scale of prioritized score, the rating and color coding are assigned to the importance of each risk occurrence and impact. Threats indicating an higher impact and possibility are classified as high-risk and requires urgent attention, while lower score risks can be monitored and checked for possible spike and impact on the project.
* **Risk categorization and Risk Urgency Assessment**: Risk categorization classifies each likely threats to the projects. It helps to identify section of the project been exposed to threats and requires urgent attention. The work breakdown structure (WBS) and Risk breakdown structure (RBS) are crucial tools for achieving these assessment models. They help to develop the appropriate risk response at any point in the project lifecycle.

**2.4 PROJECT AND MEGAPROJECTS FAILURE FACTORS**

InPMps could be very beneficial to the public and despite their relevance to the society, InPMps encounter multiple uncertainties during their development. They attract the interests and attention of stakeholders including the public due to the significant project cost, the direct and indirect influence on the community and environment. InPMps are characterized by complex construction methods, uncertain risk occurrences, ambiguity in designs, dynamic interfaces, substantial policies and external pressures (Floricel and Miller, 2001). These features are subject to a number of impacting factors such as construction means, undefined scope, human, materials and equipment management, project scope, project funding, other risk uncertainties and their interactions (Capka 2004; Flyvbjerg, Bruzelius, and Rothengatter, 2013), large scale, long time span, multiplicity of technological disciplines, the number of participants, multi-nationality, the interests of stakeholders, sponsor interest, escalating costs over time, country risk, uncertainty, and high levels of public attention or political interest ([Van Marrewijk et al., 2008](https://www.sciencedirect.com/science/article/pii/S0969593113000048#bib0355)). All features should adequately correlate with the risk management plan and procedures, because the most concerned issues within the construction industry is the disconnection between the uncertain risk events and the impact they produce on the projects.

Foremost reason for the failure and complexity of InPMPs is the large magnitude and scope of the projects. InPMPs such as airports, bridges, tunnels, or rail systems are massive, and of a monumental endeavor. Within their lengthy construction period, the variations in the political and economic landscape, change in laws and regulations, and possibly a stakeholders change project objectives could initiate a failure in projects and megaprojects. Further contributing to these complexities is the unclear, and interrelated activities to complete the project. There are newer cutting-edge technologies applied in InPMPs with a performance and functionality are often hard to predict. Evidence shows that new developments and changes in technology increase uncertainty ([Shenhar, 2001](https://www.sciencedirect.com/science/article/pii/S0969593113000048" \l "bib0300)). The failures and complexities in InPMPs can be examined in a technical and social complexity. The technical complexity is related to the size and development of the project, while the social complexity is related to the interactions among the stakeholders, project team and authorities.

Globally, InPMps experience poor performance causing cost and time extensions. The symptoms of poor performance are due to multiple obstacles in these projects, such as a change in law, delay in land acquisition, approval and permit risks, technology risks as well as project disputes ([Iyer and Sagheer, 2010](https://www.sciencedirect.com/science/article/pii/S2666721521000053" \l "bib33); [Grimsey and Lewis, 2002](https://www.sciencedirect.com/science/article/pii/S2666721521000053" \l "bib29)). Poor-performing InPMPs are also results of contingencies and changes in quality, designs, costs, exchange rates, project specifications and external environmental factors ([Jaafari, 2001](https://www.sciencedirect.com/science/article/pii/S0969593113000048" \l "bib0175)). The billion-dollar cost overrun of the 2004 Athens Olympics is often cited a failure, ([Flyvbjerg, 2007](https://www.sciencedirect.com/science/article/pii/S2666721521000053" \l "bib24)), due to its debt that contributed to the Eurozone economic crisis in Greece. In his study of 258 InPMps in 20 countries, [Flyvbjerg et al. (2003)](https://www.sciencedirect.com/science/article/pii/S2666721521000053#bib25) concluded that 9 out of 10 InPMPs fail to meet their project objectives. When evaluated against their intended project cost, time of completion, revenue predictions, quality and safety goals, these projects were unsuccessful ([Davies et al., 2009](https://www.sciencedirect.com/science/article/pii/S2666721521000053" \l "bib19)). InPMps involve diverse unrelated stakeholders, both internal and external, which calls for a significant need for effective coordination between them ([Hu et al., 2016](https://www.sciencedirect.com/science/article/pii/S2666721521000053" \l "bib31); [Molla, 2020](https://www.sciencedirect.com/science/article/pii/S2666721521000053" \l "bib42)). The proper coordination between internal heterogenous stakeholders can improve economic activity and resource allocation, and the exact coordination between external stakeholders can improve land-use and prevent public riots. Inappropriate management of project funds will impact the delivery and affect the economic benefits of InPMps as well as the larger socio-economic developments.

Megaprojects are categorized as high-risk endeavor with a high probability of failure, and with a significant impact. Flyvbjerg (2017) research tends to focus more on the study of time and cost on megaprojects. The research explains the failed practice of project’s front-end loading where it presents a deceptive initial project estimates, misleading authorities, taxpayers and shareholders. Excessive cost overruns in projects and megaprojects often put the viability of InPMps at risk. [Ansar et al. (2014](https://www.sciencedirect.com/science/article/pii/S0301421517308042" \l "bib3)) noted that that 90% of all examined Dams had cost overruns in the past. The Boston's Central Artery/Tunnel Project (The Big Dig), suffered from a significant cost increase. It had an initial estimated cost was $2.56 billion, but the cost escalated to $14.8 billion in 2007 ([Greiman, 2010](https://www.sciencedirect.com/science/article/pii/S0969593113000048" \l "bib0160)). Other previous studies confirmed the same trend in power projects ([Merrow et al., 1900](https://www.sciencedirect.com/science/article/pii/S0301421517308042" \l "bib37); [Ansar et al., 2014](https://www.sciencedirect.com/science/article/pii/S0301421517308042#bib3); [Sovacool et al., 2014](https://www.sciencedirect.com/science/article/pii/S0301421517308042" \l "bib54); [Awojobi and Jenkins, 2015](https://www.sciencedirect.com/science/article/pii/S0301421517308042" \l "bib5); [Awojobi and Jenkins, 2016](https://www.sciencedirect.com/science/article/pii/S0301421517308042" \l "bib4)). [Awojobi and Jenkins (2016](https://www.sciencedirect.com/science/article/pii/S0301421517308042" \l "bib4)) found that the complexity of designs and execution, size and the physical height of the dams are some of the main risk factors initiating influencing the cost of the projects. Cost overruns in InPMps are also generated due to the economies of scale which often do no correlate with the financial economies the project produce [Taleb et al. (2012](https://www.sciencedirect.com/science/article/pii/S0301421517308042#bib56)),

Another difficulty that affects the performance of projects and megaprojects is poor cost estimates. Estimates are major elements in the policy-making process of the authorities and concerned stakeholders ([Nijkamp and Ubbels, 1999](https://www.sciencedirect.com/science/article/pii/S2666721521000053" \l "bib45)). Poor estimates affect the project feasibility ranking and the financial returns of the project which also results in inappropriate resource allocation and the commenced projects are neither unable to complete nor recover their costs. Inaccurate contracts and bidding process can raise the costs of infrastructure services as they fail to allocate risks effectively ([Akintoye et al., 2003](https://www.sciencedirect.com/science/article/pii/S2666721521000053" \l "bib1)). When InPMps are developed on a high cost, this cascades unto the customers and taxpayers and an efficiently utilized contracts methods in the pre-planning stage leads to sustainable infrastructure development because of the resultant lifecycle optimization ([Lenferink et al., 2013](https://www.sciencedirect.com/science/article/pii/S2666721521000053" \l "bib35)).

Both planned and unplanned project and megaprojects which entails high funding, numerous outcomes and highly politicized, are often cited as unsuccessful, owing to been delivered lately, over budget and under specified quality. Continuously investing in InPMps despite these failure reasons has resulted in InPMps being regarded as highly ironic and in most instances, not much work has been invested in understanding the long-term benefits or operational methods of these huge projects. For example, in 1971, a fish processing facility was built by the Norwegian government in Kenya in 1971 to provide jobs to the locals. The $22 million project was shut down after a few years due to lack of operational experience. InPMps are plagued with disasters and inadequacies, often due to uncertainties and their mismanagement within the project lifecycle processes. Risks in InPMps increases as their objectives expands, becomes complex and critical Flyvberg, B. (2017). As InPMps are within the purview of the public, project finance risks are among the easily recognized risk factors due to their large size and expenditure, and the frequent usage by the public. Financial exposures can be enormous, and a budget overrun on ventures such as the Panama Canal, Hong Kong's MTR or Dubai Airport, can lower the country's GDP (Garemo et al, 2015). The scale of project and megaprojects have maintained a global increase, with several megaprojects throughout the Globe, such as the Mexico's cancelled airport, UK's high-speed railway HS2 or Ethiopia's new Dam in the press headlines. Typically, megaprojects have multiple stakeholders such as financiers, taxpayers or investors, and such stakeholders or their nominated representatives yield the power and conduct themselves in a manner which reflects their inherent beliefs and culture.

The size and complexity of InPMps makes it difficult to conclude which risk factors actually enhances or affects their delivery ([van Marrewijk et al., 2008](https://www.sciencedirect.com/science/article/pii/S2666721521000053" \l "bib63)). Dynamics in InPMps have exposed the beginning of new and uncertain events that have continuously impacted the decision and outcomes of the InPMps ([Hertogh and Westerveld, 2010](https://www.sciencedirect.com/science/article/pii/S0263786317313297" \l "bb0185)). Within the long and short term of a project, these uncertainties are revealed, combining the temporary and changing forms of organization ([Brookes et al., 2017](https://www.sciencedirect.com/science/article/pii/S0263786317313297" \l "bb0060)). The various moments and results of risky events considers InPMps a set of episodes or short-term events ([Ruuska et al., 2011](https://www.sciencedirect.com/science/article/pii/S0263786317313297" \l "bb0305)). These moments relates to the stand point and reputation of the stakeholders involved ([Aaltonen et al., 2016](https://www.sciencedirect.com/science/article/pii/S0263786317313297" \l "bb0005); [Miller and Hobbs, 2005](https://www.sciencedirect.com/science/article/pii/S0263786317313297" \l "bb0245)), they are also associated with the advancements in numerous stakeholders' perspective of success with a reduced perception of risk.

**2.4.1 EXISTING NARRATIVES ON INPMPS RISK FACTORS AND DELAYS**

Infrastructure projects and megaprojects are many times influenced by risk factors that impacts projects metrics. These impact affects one or all of the scope, cost, schedule, quality and safety of the projects. The resultant effect on the project metrics are cost overrun, schedule extension, reduced project quality, accidents and causalities within the project. These persistent effect of risk factors impacting InPMPs have been recognized as a global challenge and they are the most uncertain, frequent, and costly problems associated with both the public and private construction sector. Accordingly, project execution is a risky venture and the absence of the appropriate method to assess and address these risks has led to a lot of undesirable results in the project execution.

Over the years, various studies and analysis have been performed to ascertain the possible risk factors impacting project metrics in construction in various parts of the world. In their research, Assaf et al. 1995 studied the causes of delays in large building projects in Saudi Arabia and identified material related delays as the main risk factor causing delays to projects in Saudi Arabia. Ogunlana et al. (1996) identified 26 risk factors affecting InPMps in Thailand. The risk factors were grouped into 6 sources and the research concluded that the construction problems in Thailand and its comparable developing countries can be nested in three layers: (a) problems of shortages or inadequacies in industry infrastructure (mainly supply of resources); (b) problems caused by clients and consultants and (c) problems caused by contractor incompetence/inadequacies. Similarly, Odeh and Battaineh (2002) concluded that 28 risk factors affected the construction of projects in Jordan. The study noted that owner’s interference, inadequate contractor experience, financing and payments, labor productivity, slow decision making, improper planning, labor productivity and subcontractors are among the ten most important factors impacting the success of InPMps in Jordan.

Aibinu and Odeyinka (2006) assessed the risk factors associated with causes of delays by focusing on actions and inactions of project team members and the external factors. The study analyzed data from completed building projects to assess the extent of the impacts and 44 risk factors were identified to have contributed to the overall delays on the project they were involved with. In a similar vein, Chan and Kumaraswamy 1997 evaluated the relative importance of 83 delay factors in Hong Kong. Five major delay factors were identified in the research, namely: poor risk management, poor supervision, unforeseen site conditions, slow decision-making involving variation, and necessary variation works. Kumaraswamy and Chan (1998) studied eight risk factors categories: project related factors, client related factors, design team related factors, contractor related factors, materials, labor, plant and equipment, and external factors. Out of these eight factors, six important factors contributing to the delays in building and civil engineering works are unforeseen ground conditions, poor site supervisions, low speed of decision making involving all project teams, client-initiated variations, necessary variations of work, and inadequate contractor experience

Bramble and Callahan (1992) noted in their research the duties of stakeholders to the design and construction process. They noted risk factors associated with owners, designers, contractors, subcontractors/vendors and the risk factors not associated with any of these professionals. Owner-caused risk factors were noted as late release of site to the contractor, late approvals, financial difficulties, contract administration responsibilities, change orders, and interference. Designer-caused risks were noted as design defects, slow correction of design errors, tardy shop drawings review, and delays due to test and inspection. Failure to evaluate the site and design, contractor management problems, inadequate resources, and construction defects were apportioned to the contractors, and weather, act of God, strikes, and labor disputes were identified as risks not caused by any of the design and construction parties. Hegab and Smith (2007) defined the delaying risk factors in micro tunneling as the non-working time of a micro tunneling project other than the scheduled stops. Risk factors related to micro tunneling incudes mechanical failure of system components, leakage of hydraulic hoses, blockage of slurry pipes, and waiting time for excavated materials hauling equipment.

Studying the non-excusable delays that affected contractors’ performance, Abd. Majid and McCaffer (1998) assessed and note the risk factors such as materials, equipment, and labor-related were the major causes of contractors’ performance delays. Bordoli and Baldwin (1998) explored the delays causes in building projects in the United States, they concluded that risk factors such as Weather, labor supply, and subcontractors were the prominent factors affecting time and cost overruns on high-rise projects. In Indonesia, Kaming et al. (1997) learned that design changes, poor labor productivity, and inadequate planning and resources were found to be responsible for construction project delays. An evaluation of the important causes of delay in public utility projects in Saudi Arabia revealed that the common factor categories of delay were contractor performance, owner’s administration, early planning and design, government regulation, site and environment conditions, and site supervision (Al-Khalil and Al-Ghafly 1999)

In Nigeria, Mansfield et al.1994 looked into the risk factors causing cost overruns in public highway and building projects. Four main risk factors agreed on by the contractor, consultants, and public clients in the survey were the financing of and payment for completed works, poor contract management, change in site conditions, and shortages of materials. Odeyinka and Yusif (1997) also studied the risk factors associated with delays in Nigeria housing projects. They categorized the factors into clients, consultants, and contractor risk factors. Clients risk factors were related to variation orders, slow decision making, and cash flow problems, contractors risk factors were financial difficulties, material management problems, planning and scheduling problems, inadequate site inspection, equipment management problems, and shortage of manpower. Consultants risk factors include: incomplete drawing, slow response by consultant, variation orders, late issuance of instruction, and poor communications. Risk factors such as inclement weather, acts of God, labor dispute, and strikes were found to be minor factors responsible for delays.

Toor and Ogunlana (2008) developed questionnaire surveys and interviewed experts in construction project in Thailand to explore the substantial risk causing construction delays. Factors related to designers, contractors and consultants were also evaluated and among the top problems, lack of resources, poor contractor management, shortage of labor, design delays, planning and scheduling deficiencies, changed orders and contractors’ financial difficulties were ranked highly impactful while multicultural and multilingual environment causing ineffective communication’, ‘large number of participants of project’ and ‘involvement of several foreign designers and contractors’ were rated among the less problematic risk factors from the 75 risk items. Le-Hoai et al. (2008) identified 21 risks causing delays to large construction projects in Vietnam. From the results, it was noted that poor site management and supervision, poor project management assistance, financial difficulties of owner, financial difficulties of contractor, design changes are five most frequent, severe and important risk factors.

Sweis et al. (2008) classified the risk factors influencing residential projects residential projects, the most common risk factors were assessed by using both the analysis of data and interviews and the results were financial difficulties faced by the contractor and too many change orders by the owner. Severe weather conditions and changes in government regulations and laws ranked among the least delaying risk factors. Kaliba et al. (2009) also classified the risk factors leading to cost overrun and time extension in road projects in Zambia. The study concluded that that bad or inclement weather from heavy rains and floods, scope changes, environmental protection and mitigation costs, schedule delay, strikes, technical challenges, inflation and local government pressures were the major risk factors impacting Zambia’s road construction projects. Al-Kharashi and Skitmore (2009) conducted a study of previous projects required to plan future projects in Saudi Arabia. The research found that the risk factors needed for optimization of future projects are the lack of qualified and experienced personnel attributed to the considerable amount of large, innovative, construction projects and associated current undersupply of manpower in the industry.

Soliman (2010) identified 29 delay risk factors affecting construction projects in Kuwait through a refined data analysis of previous research. The risk factors were categorized into 6 groups considering the contractors and consultants. The study showed that the financial and design related causes of delays are the most important and frequent causes. Top risk factors related to the contractors are delay of document submission from consultant, delaying of payments from owner, conflict between contractor and consultant, in-appropriate owner representative’s management style and owner financial problems, While the five top delay causes from consultants category are: owner financial problems, contractor financial problems, inefficient management capability of contractor staff, conflict between contractor and consultant, and no planning before project start.

Orangi et al. (2011) noted the most important risk factors affecting pipeline projects in Victoria, Australia are design changes, design errors, design submission delays, lack of communication between designers and contractors, lack of communication between client and project team, customer/end-user related issues, inadequate geotechnical investigations, issues regarding client approvals, issues regarding permissions, adverse weather conditions, delays by material suppliers, poor site management practices, planning and scheduling errors, construction rework, cultural and heritage management issues and subcontractor issues. Similarly, Hasseb et al. (2011) concluded in their research that considered 37 risk factors that most of the delays were related to client factor which must have strong economical ability and financial arrangement for project. Factors related to consultant are due to not understanding the client project goals, not having proper project information, absence of some detail in drawing. And the contractor’s related risks are deficient in obtaining up-to-date equipment, unwarranted material used in construction. Mahamid et al. (2012), summarized in their research after considering factors 52 that both the contractor and engineers agreed on the top five severe delay causes as political situation, segmentation of the west bank and limited movement between areas, award project to lowest bid price, progress payment delay by owner, and shortage of equipment.

Anastasopoulos et al. (2012) analyzed data from 1722 highway projects in Indiana. The estimation results showed that the likelihood and duration of project time delays are significantly influenced by risks such as project cost, project type, planned project duration, and adverse weather. Niazai and Gidado (2012) noted that out of 83 assessed risk factors in Afghanistan construction sector, the findings show that the main critical factors that cause construction delays in Afghanistan are security, corruption, poor qualification of the contractor’s technical staff, payment delays by clients, and poor site management and supervision by contractor.

**2.4.2** **ESTABLISHING THE RISK FACTORS**

Several studies have been conducted and conclusions drawn to identify the various risk factors negatively impacting the InPMPs at different parts of the world. This research aims at establishing and analyzing the behavior of 32 risk factors in the project lifecycle of InPMps. The assessment will present some knowledge for planning and the proactive management of risk factors throughout the lifecycle of projects and megaprojects. Table 2.4 shows the summary of identified risk factors from section 2.4.1. Hastak and Shaked (2000) summarized these risks factors into 73 factors and further categorized them into 9 categories namely (Table 2.1); Operational risks, Political risks, Cost/Financial risks, Technology risks, Contract and Legal risks, Resources risks, Business/Cultural risks, Market Potential risks, Design, construction and Quality risks.

The 32 risk factors adopted in this research were references from the literature reviews in section 2.4.1 and summary of the risk factors in Hastak and Shaked (2000). This is a generic and not an exhaustive list of all identified risks in section 2.4.1. Hastak and Shaked (2000) grouped the identified risks into 9 categories, while the established risk factors in this research is categorized into 5 (Figure 2.2). It was necessary to accomplish and establish the 32 risk factors in order to simplify the data collection, analysis, and the quantification of risk factors. Establishing these factors also enables the realization of the research objectives, and their application during the lifecycle phases InPMps.

(Table 2.0) Identified risks Factors

Graphical user interface, text, application

Description automatically generated(Table 2.1) Hastak and Shaked (2000) Summary of Risk of Factors.

(Table 2.2); 32 Established Risks Factors

**2.5 PROJECT LIFECYCLE PHASES (PLP)**

Knowledge of project lifecycle phases (PLP) in InPMps is crucial for all stakeholders and the participating team involved in the construction. Construction Lifecycle phases (PLP) has been widely used in the management of construction projects, it is believed to reduce the lifecycle cost of InPMps and improve the owner’s serviceability (Chalfant 2001; Xie and Simon 2006). InPMps are traditionally divided into several individual phases such as pre-planning, planning, design, construction, commissioning, maintenance and demolition and these phases can be implemented separately with or without an overlap. PLP integrates all the required elements of managing a project from the project inception to close-out, making coordination and information sharing between owners, engineers, and contractors possible. It has been developed as a business method for overseeing the total life cycle of products (Garetti 2004; Kovacs et al. 2006), it has been employed in the manufacturing industry (Hayes and Wheelwright 1979a,b; Labuschagne and Brent 2005) and its extensive application in the construction industry has been discussed to include different models; control-oriented models, quality-oriented models, risk-oriented models, etc., (Bonnal et al. 2002). The competent management of a PLP process can be very beneficial, mostly in times of controlling large and complicated projects, since professionals in different disciplines can proffer valuable opinion and services to the project. InPMps PLP can be represented in (figure 2.3)

**2.5.1 Construction Initiation and Preplanning Phase (CIPP)**

IPP has been referred to as the pre-project planning phase (Jesper Kranker Larsen, 2015) (Hyojoo Son, 2012), conceptual planning phase (Peerasit Patanakul, 2010), feasibility analysis, schematic design and the early project design (G. Edward Gibson Jr., 2006). This is the phase that includes all tasks between initiation and the detailed design of the project. Haughey 2010 noted that the initiation and preplanning phase of an InPMp covers the business case, scope of work, deliverables, resources, milestone strategy, project budget, risks assessment, quality and dependences that requires a methodology as an important principle that can be tailored to a specific situation (Wideman 2005). The CIPP phase develops the information that can be used to address risk and determine the resource allocation for project optimization. The CIPP is essential during the development of an InPMp (Williams and Samset 2010), it is the phase that authorizes the project and other relative activities (PMBOK, 2013). It plays a crucial role in ensuring the success of a project and megaprojects (Merrow 2011; Morris 2013).

This is the project phase that establishes the intended quality of the project that satisfy the owners and end users after delivery. Abowitz and Toole (2010) indicated that the CIPP initiates the construction planning, execution and defines the final products of the entire project. The initiation and preplanning phase of a project determines the significant projects, demand and justify the reasons for collecting all necessary information for the project development. Ideally, at this stage, the stakeholders are identified, and the project team might be constituted, project needs are defined, and prioritized by the stakeholders. Risk issues are minimally evaluated and the benefit of project to host communities is also accessed in the IPP.

Identifying relevant stakeholders should be done early in the CIPP to activate their roles, commitment of implementing the construction process and validate the operation and maintenance phase after project delivery. Risks identified in the CIPP can be possibly resolved before they impact the project execution thereby maximizing projects to schedule and costs savings. (ChungSuk Cho, 2001). The CIPP entails the clearly define project milestones of the project. Project milestones are employed in construction management to mark major achievements along the projects schedule. The understanding of this project phase enables the agreement and coordination of milestone planning between the client, user and contractor. Milestone significantly affects the execution and monitoring of InPMps and there might be several milestones in a project, hence the need to engage the contractor at the inception of the project to focus on certain milestone which increases commitment to project timeline and resource optimization in areas requiring fast-tracking. The CIPP also involves project scope definition, referred to as statement of work or the project charter (Verzuh, 2008). In the IPP, project scope involves establishing and documenting a list of the specific project objectives, qualities, duties, deadlines and budgets. The extensive identification of project scope during the CIPP allows for an accurate project cost and schedule, conversely, incomplete or poorly defined project scope results to scope/change orders, increased project cost and time extension. The CIPP is a foresight method for solving construction challenges and planning for risk mitigations, and to achieve these, all construction parties are to contribute their quota towards the initiation and pre-planning phase of the InPMps.

Diagram

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Figure 2.3 Construction Lifecycle Phase (Source; theconstructor.org)

* + 1. **Construction Planning Phase (CPP); Feasibility Study, Design and Engineering**

The construction project management process begins with planning, followed by execution and control (Sears et al. 2015). The complexity of InPMps and the achievement of project objectives requires the coordination between the designer, engineer and contractor at the early phase of the projects. This coordination phase which further requires the development of details to achieve project objectives is the construction planning phase (CPP). This phase has the detailed direction that guides the project team in what must be done on the project, when it must be done and what resources that must be used (PMI 2013). At this stage of managing the project, project members will discuss and initiate a work break down structure (WBS), schedule project task using the program and review technique (PERT) and apply resources, assess potential risk and create other project management methods (Ibadov and Kulejewski).

The output of CPP are series of crucial documents for managing all stages of the project and the outcome of cost, schedule, quality and safety are dependent on the implementation of the construction planning phase. The CPP is a significant project stage and a part of its effectiveness has was acknowledged by Hwang (2012) who noted that an effective CPP has a positive correlation with cost and schedule savings. The CPP procedure also helped 10 out of 12 Singapore firms to reduce project durations approximately up to 15%. Furthermore, 11 out of 12 companies that applied the principle of project planning had a reduction in overall project cost up to 15%. This was also in coherence with the Construction Industry Institute (CII) recent best practice report results that indicated that 609 projects cost of $ 37 billion achieved 10% less cost, 7% shorter project duration and 5 % fewer scope changes due to effective CPP (CII 2012).

Project planning, as an initial element of project management has been a component of success factors, the document produced at this stage directs the implementation of complex projects during the separate stage and integrates several professionals on the project. This stage allows the continuous comparison of work done and work planned at separate reporting dates. This helps to control variations in the project objectives and maintains a defined track, ensures the various project metrics in terms of time, cost, quality, and safety in construction (Newton 2016; Siew 2016). An efficient CPP provides a valuable guidance and mechanism to improve the success of any construction projects, it aims at lessening uncertainty, provides a risk assessment means for identifying, analyzing, and reacting to threats within the construction phases (Marcelino-Sádaba et al. 2014; Zwikael and Sadeh 2007) and a proper CPP will notify the team members about project goals, responsibilities, and processes unite all during project WBS creation and negotiating during the project planning process (Meredith and Mantel. 2012). Consequently, the CPP process could promote project success through unanimity among the project team. To achieve a successful InPMps, several construction planning tools, and techniques have emerged in the last decades. These tools include the building information modeling (BIM), project control techniques using past project date and project control systems. The effect of these tools varies differently on project cost, schedule, quality, safety and the overall success of the project. There are a few other factors that affects the planning phase of a project, but an inadequate scope definition which is usually done in the construction planning phase mostly affects the development and success of InPMps.

* + 1. **Construction Execution and Procurement Phase (CEPP)**

This is the implementation phase of the project where the required work to achieve the project objectives are performed. During this stage, it is essential to maintain communication among the project team, projects are monitored to avoid variances from planned cost, schedule, quality and safety. The CEPP is where parts combination and activities are carried out, all scope and planning are put to test here and this is the integration part of the project where the team aligns to a single goal. Deviations to projects goals at this stage are immediately rectified to avoid it effect on the project metrics.

Implementing the details of the project charter for the owner or project stakeholders is done in this stage the InPMps and regardless of a perfect planning, the InPMps will be a failure if the execution processes are not appropriately implemented. Clients and stakeholders should be involved during the execution phase, this is to avoid miscommunications between the project team and stakeholder. This is the costly phase of the project, and an open communication is crucial at this stage to foster project delivery. Regular meetings, progress reports and updates should be done at agreed time, and by this, stakeholders are within the communication loop of the project. In addition to the above, the construction phase should have clear roles, responsibilities and accountabilities to the project head.

The construction execution and procurement phase of InPMps are the most risky phase, and the overall risk assessment and management are carried out at this phase. At this stage, construction manager evaluates the impacts of evaluated risks from the planning phase. Apart from risk mitigation, project head must be cautious to keep the project metric on schedule. Some of the ways to maintain project schedule in the CEPP is to monitor the contractor's safety program, monitor the scope, time and project cost, project insurance and risk assessment methods. Apart from the risky processes in the construction execution phase, the construction of InPMPs is a linear process; an aspect of the construction must be completed prior to commencing another one. This also means that a team of worker or resources must wait while other team completes their project activities.

The construction phase includes the monitoring and control of construction activities. It the lengthiest section of the execution stage because all procedures must be observed to ensure project meets stakeholder specifics. The following steps are crucial during the monitoring and control process in the execution phase.

***Time management:*** in the CEPP, time spent by the project team to complete a task is documented, and this time is controlled to meet up with project scheduled. All these times are documented for project monitoring and quality control.

***Cost management:*** Costs are important in the execution phase. It is important to identify the required cost for each works required for the project. The cumulative cost of work packages should sum up to the overall project cost. Cost management and payment systems must be monitored in the construction execution phase.

***Quality management:*** the quality of construction materials must be monitored. The installation of materials also requires optimum controls, quality reviews and audits of quality standards must be done to ensure all means meets the specific factors as specified by the project and stakeholders.

***Change management***: whenever a change order or scope change is required in the execution phase, all documentation relating to the impacts on cost, schedule and quality must be identified. This process is the change management system which is usually carried out in the execution phase and a change or log register is used to record all the changes.

***Risk management:*** monitoring the risk issues prevents drawbacks and delays in the execution of InPMps. The risk register must contain all identified risk and the respective responses.

***Procurement management:*** A procurement management plan must be made available to monitor all vendor, material supplied and other related issues with the construction arising from substandard construction materials.

* + 1. **Close-out and scope validation phase**

This phase of the project wraps up the construction life cycle, it closes and completes all activities in the project. At this phase, manifolds of project closeout documents begins to unfold for the proper project hands-off and the project leaders must be ready to deliver project products to the clients and other stakeholder. The project team must finalize all schedule, cost and quality plans at this phase of the project. After the project has been internally approved by the project lead, the client must also validate and sign in the delivery of the project. During the closeout phase of the project, the client and the project engineer reviews the construction specifications and the list of all required inspections, tests, materials, maintenance tools, and warranties after project delivery.

The main reason for this phase is to validate project completion and owner’s satisfaction. It ensures that all stakeholders are adequately informed of succeeding task after the project has been handed over. It is also crucial to capture the lessons learnt at the close out phase, document best practices and keep records to improve organizational assets. During the project close out, a competent project manager must establish that the work is complete, maintains organizational standards, and must reference the past as an experience. The project team could be liable for compliance issues if they failed to conduct a proper close out for the project. With the collaboration of the project team and project owners, the closeout activities can be monitored by:

***The punch list:*** the project members must diligently pursue completion of the project’s punch list. At the closeout phase, remaining and unresolved project works must be completed otherwise the owner stands to withhold a certain amount known as the retention fee. All items in the punch list must certify the project quality and specifications.

***Submission of the as-built drawings***, at the close-out phase, it is important that the project team submits the as-built drawings. These are the drawings that reflects all revision to the original drawings, they include all design changes and alterations. The architect and engineer must have completely reviewed all as-built drawings produced prior to the project completion. Variations in designs and construction should be included in the as-built drawing and they must be a reference document for future repair.

***Complete the paperwork***; part of the closeout phase is the complete signoff on all project documents, and these must be approved by all concerned. Closing all contracts with other vendors and partners must also be completed at this stage, payments must be finalized, and all invoices must be closed out.

The close out phase of a project also involves the scope validation. The validation process aims at approving or disapproving the completed project works. It is the responsibility of the owner or the project user to carry out on the validation process. During the validation stage, the owner compares the completed work items with the original design or specifications with the aid of the designers or project engineer. Validation done in the close out phase does involve some cost accrued to either the contractor or the owner and a basic outcome of the project validation must result in an approval or rejection of some or all of the project works. Close out validation requires the commitment effort of all project team and stakeholders. Adequately validating project scope in the closeout phase results in the proper management of project cost.

**2.6 RISK FACTORS AND IMPACTS ON PROJECT METRICS**

The concept of project metric is crucial to project management, it is the basis for framing a project, it constitutes the core of a project plan and it an unavoidable process of monitoring and controlling the project (Marchewka, 2006). In the design and execution of InPMPs, risk factors and their impacts must be considered and adequately planned to avoid or lessen the impact of disruption on the project. Hussein (2013) identified six key risk factors that impacts the success of projects, these risk factors, if not accurately recognized and minimized at the pre-planning phase will trigger further problems in other phases of the project. Lack of cognizance to the project metrics such as project scope, cost, quality and safety is a form of risk factors in its form that complicates the management of InPMps. In the paper, Couillard (1995) established through a study, the relationship between having a deep understanding of project metrics and an effective project risk management, Hussein (2012) also presented the various outcome of how risk misalignment impacts projects metrics and completion.

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Figure 2.4 Project Triple Constraints Figure 2.5 Project Metrics

The project metrics is a refinement of the project triple constraints. As shown in figure 2.4, the theory of the triple constraint is a triangle of time, cost and scope within which all projects must be accomplished (Dobson, 2004). Metrics are the standard and the best model for evaluating project performance. Cost, time, Scope have been considered as the triple constraints. However, in addition to these, the safety metric was added to the triple constraints making it an addition to the project metrics. In figure 2.5, this addition was justified by series of past literatures. Othman et, al (2017) noted that safety affects all levels of stakeholders and if all safety procedures are adequately adhered to, it will minimize cases and prevent the abrupt delays on construction projects. Shenhar, Levy & Dvir (1997) maintained that achieving the apparatus of budget, schedule and scope are important in project execution, Levitt & Samelson (1993) noted that health and safety procedures aids the quality of work, these fosters work performance and the efficiency at work. Levitt & Samelson (1993) further stated that health and safety conscious contractors are more efficient, they are more attractive to clients and the health and safety consciousness give productivity morale to the site workers.

Project performances are calculated and reported based on the metrics status that are are significant success criteria for any project. A project manager achieves success in project delivery by managing all areas of the project metrics; cost, time, quality and safety. A failure in any of these could impact the other metrics and subsequently a failed project (Dobson, 2004). The most profound measure of project success is the project metrics, time addresses the duration for completion, cost focuses resources and finance, quality addresses the delivery of project scope, and safety addresses the integrity of the company and its awareness to safe workplace. An ineffective management of the project metrics as an interrelated system, provides the risk of the project becoming separated from its charter.

**2.6.1 PROJECT SCHEDULE AND SCHEDULE OVVERUN**

Project scheduling is a sequence of project works organized in a timeline within the project baseline. It shows the project execution details relative to when it should be done. Scheduling is establishing the timing and sequence of operations in the project and their assembly to give the overall completion time (Mubarak, 2010). Project scheduling is not project planning. Project planning has been defined as choosing the method and an order for project execution (Antill and Woodhead 1990, p. 8; Callahan, Quackenbush, and Rowings 1992, p. 2). PMBOK (4th edition, 2008) also described planning as the method of establishing scope, project objectives, and a set of action required to attain the objectives. As project planning focuses on the efforts such as cost estimating, scheduling, project control, quality control, and safety management, project scheduling focuses on one part of the effort. Project planning satisfies the objectives of what is going to be done? how will it be done? where would it be done? who will do it? and when? Project Scheduling deals with the when on a detailed level and it is often interchanged with project time / timeline of execution as illustrated in figure 2.6

Diagram

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figure 2.6: Project Planning Schedule (Source: Saleh A Mubarak. (2010) Construction project scheduling and control.)

|  |  |
| --- | --- |
| Importance of Project Schedules to Stakeholders | |
| **Contractor** | **Project Owners** |
| Overall estimate of project completion | A view of project end date |
| Determine the start and end of constraints, milestones and other activities | Tool for monitoring contractors’ commitment to completion |
| Time and coordination of vendors and other trades | A tool for project cash flow |
| A tool for project cash flow | Project controls and management tool |
| Monitor project performance and need for improvement | Impact assessment of change orders |
| Project controls and management tool | Time extension and verification of delays and claims |
| Assess and evaluate impact of changes to project |  |

Table 2.3: Project Schedule and Stakeholder’s Influence

InPMp delivery is largely dependent on the schedule and an adequate understanding of timeline is not just crucial, but often critical in both the planning and execution phases of the project. Inappropriate project schedule results in errors and an acceptance of unrealistic project baseline, it also prevents an accurate estimate for resource allocation, it raises project cost and disrupts construction flow. Following these are contractual penalties, harm to reputation and client’s disappointment (Mubarak, 2010). Table 2.3 illustrates the importance of project schedule to the owners and contractors. Project scheduling is not just a valuable instrument of project management in the coordination and communication of processes within the organization, it is also used for both the planning of project activities and assigns resource assignment to construction works. Hence, the project scheduled can be the information source for pre-booking the key worker or equipment needed to complete a construction task.

Project schedule overruns are not uncommon on construction projects, and it continue to persist. However, in-spite of the huge importance of completing InPMps at the appropriate planned time, it is common to see construction projects failing to achieve their objectives within the approved timeline (Memon et al. 2012). Schedule overruns was defined by Alkhathami (2004) overruns as the required extra time required to complete a project, this extra time is goes beyond the original planned completion date. Assaf and Al-Hejji (2006), identified schedule overrun as the time extension either beyond the contractual completion date or the date beyond what the project stakeholders agree upon for delivery or completion. Mohamad (2010) also explains that schedule overruns are an act or incident that extends the project’s completion time or the contractual time.

Schedule overruns are caused by incidents that happens before or during the execution phase of the project and region to region (Herrera, 2020). Schedule overruns are common in InPMp, and their effects varies from one project to another. Project schedule is one of the critical variables for the measurement of project performance and it is also one of the most recurrent issues on construction projects with impact on time, cost, quality, and safety (Ozcan-Deniz et al 2012). These impacts are not recorded in the construction industry only but also presents an impact on the quality and cost of an overall country or economy. Impediments on project schedule cascades an increase on the project cost and deters project quality, hence, it is important to identify the significant factors for schedule overruns in the InPMp sector.

Several factors promote to schedule/time overrun InPMps, Subramani et al 2016, identified that low labor productivity and design factors are the most influencing factor causing time overrun in projects. Shortage of resources, reduced of human resources, skills and poor workforce productivity were identified by Faridi and Sayegh (2006) as the main factors affecting schedule overruns. Mohammed, (2012) noted that in Nigeria, improper planning and lack of communication affected the project schedules. Similarly, Doloi et al (2012) concluded that project schedules in India were mostly influenced by the inefficient site management, lack of clarity in project scope, improper planning, lack of communication, lack of commitment, poor labor productivity, poor site coordination, substandard contract, and slow owners’ decision. In Malaysia, Memon (2014) identified change project scope, owner’s financial difficulties, delayed decisions and unforeseen ground conditions as the prevailing factors causing schedule overruns. On the contrary, Murali and Kumar (2019) concluded that site conditions, material management, contractor financial difficulties, unskilled labor strikes, machines and equipment difficulties delayed the progress of the project. Theodore (2009): Motaleb and Kishk (2010) and (Ali et al, 2012): identified and categorized the factors affecting project schedule into: client, consultant, contractor, external and other influences.

Client’s related project schedule overruns: Wei (2010) indicated that the late revision and approving of design documents are some key issues from the client affecting project schedule, and Mohamad (2010): Motaleb and Kishk (2010) noted that owner’s change orders during the execution phase contributes to schedule overruns. Haseeb et al. (2011): Assaf and Al-Hejji (2006) and Sambasivan and Soon (2007) identified a similar factor: delay in progress payments by owner as a major cause of schedule overruns. Denini (2010) also reiterates that delayed decision by owner and delay progress payment affects the project schedule. However, Ayudhya (2011) concluded that owner’s delay in progress payment, adverse weather conditions, scope validation and insufficient construction documents are leading causes of schedule overruns. On the flip side, Ren et al. (2008) stated that the owner’s unrealistic project duration, prime and provisional sums, contractors/vendors selection, and owner’s irregular payment are factors leading to project schedule overrun.

Engineer/Consultant’s related project schedule overruns: delay in approving changes to scope by the engineers was highly ranked to affect project schedule by Theodore (2009) and Wei (2010), and poor contract and project management, inaccurate estimates, design errors and delayed inspection by the engineers were identified by Le-Hoai et al. (2008) to have impacted project schedule. Further, Wong and Vimonsatit (2012) concluded that the major consultant related causes of schedule overruns include: altering scope specifications during execution, skill shortages, shortage in workforce, financial difficulties, unrealistic project duration, poor communication, underestimation of project’s complexity and project’s cost, materials shortage, and unforeseen ground conditions. Similarly, Assaf and Al-Hejji (2006) identified that delay inspection and testing by the consulting engineer led to schedule overrun and Motaleb and Kishk (2010) established that insufficient consultant experience affected project schedules was the major cause of schedule overruns associated with consultants. Ren et al. (2008) revealed that the engineers causes of schedule overruns are delay in approval of documents, incomplete drawings, alterations to construction drawings and specifications, incomplete contract documents, and time for inspection.

Contractor’s related project schedule overruns: Theodore (2009) and Assaf and Al-Hejji (2006) identified the contractor’s actions leading to schedule overruns and ranked them as follows; difficulties in financing project, conflicts in sub-contractors schedule in execution of project, rework due to errors during construction, conflicts between contractor and other parties, poor communication and coordination, ineffective planning and scheduling of project, improper construction methods implement, delays in sub-contractors work, inadequate contractor’s work, frequent change of sub-contractors, poor qualification of the contractor’s technical staff and delays in site mobilization. Delays in sub-contractors’ works was ranked by Wei (2010) as the main cause of schedule overruns and Denini (2010) also revealed financial difficulties faced by the contractor, poor project planning and scheduling, inadequate contractors’ experience, inaccurate cost estimation, poor site management and supervision were mainly influencing project schedules leading to overruns. The study by Motaleb and Kishk (2010) indicated that late delivery of materials was also the cause of project overrun, and Wong and Vimonsatit (2012) attributed financial difficulties, delayed construction decision, workforce shortages, design errors, unforeseen ground conditions, poor stakeholders’ management, poor communication, and unrealistic project duration to have negatively impacted project schedules.

Other Factors related to project schedule overruns: The study by Sambasivan and Soon (2007): Assaf and Al-Hejji (2006) and Wei (2010) noted that shortage and quality of materials affected project schedule. Also supporting this is Alwi and Hampson (2003), they concluded that late materials delivery, poor quality of materials, handling and scheduling of construction materials contributed to schedule overruns in InPMps. Assaf and Al-Hejji (2006) and Sambasivan and Soon (2007) revealed the impact of ground conditions and subsurface conditions on project schedule, and Le-Hoai et al. (2008) observed that unforeseen site conditions, price changes, inclement weather, government intervention were major causes of project schedule. Wei (2010) also noted the effect of lack of high-technology mechanical equipment and low productivity, and efficiency of equipment as causes of overruns.

**2.6.2 PROJECT COST AND COST OVERRUNS**

Project cost is the contract price that was specified in the contract document required to complete a construction project. It is usually estimated by the cost estimator, prepared and submitted for review by the contractor and approved by the engineer or cost consultant. Project costs are made based on market rates and are expected to prevail during the duration of the Construction Works. Project cost includes the management and supervision cost, vendors and other contractors cost, and an allowable overhead and profit for the executing company. To some extent, the cost of a project varies from the decision-making stage through execution to operation and maintenance stage and controlling the project cost is done in all these stages. Project cost information can be accessed from the project management details, and the use of these information is crucial to determining the viability of the project and its degree of impact on the economic.

Project cost is the baseline with which the performing organization depends on to regularly check the overall construction operation, hence the need for controlling the cost of a project. Controlling project cost is required for the growth and survival of the performing organizations, and it helps to eliminate unwanted process within the construction process. Cleland and Ireland (2002) defined cost control as the process of evaluating, monitoring, and comparing planned actual cost of project execution relative to project performance. The principle of controlling also provides timely warning to budget adherence and allows for corrective measures. Project cost and its control have been influenced by many factors in the different stages of construction and despite the negative results of these influence, cost overrun continues to be an intricate part of the infrastructure project and megaprojects industry.

Table

Description automatically generatedSome previous studies indicated that cost increase occurred drastically in infrastructure projects, such as the Norwegian roadway projects (odeck, 2019), transportation projects in the USA (Ellis 2007), and in Australia (Terril and Danks, 2016). Flyvbjerg et al. 2018, concluded that for a randomly chosen construction project, the probability of a cost overrun is about 86%. The most significant cost overrun has been noted in rail projects and the slightly lower increase has been in the transportation projects. A study also observed that 50% of the transportation projects in the United States had cost overrun (Sinnette 2004), and the continuous report of cost escalation in public project had caused the public to loose trust in the performing organizations. The Boston Big Dig with an initial project cost of $2.6 billion and after 14 years of execution, its budget at completion was about $14.6 billion (Board on Infrastructure and the Constructed Environment 2003). Project cost overrun have plagued the construction industry for several years, it triggers disruptions to infrastructure programs and often lead to a delay or suspension of InPMps. Flyvbjerg et al. 2002 indicate that the global transportation projects cost are 28% higher than their budgeted cost. As shown in Table 2.4, rail projects have the highest cost escalation of about 44.7%, bridge projects follow at 33.8% and the road projects with an average cost increase of 20.4%. Transportation projects have consistently had a cost increase of 27.6%, and Flyvbjerget al. 2002 concluded that there are no indication that cost overrun is on a decline in InPMps.

Table 2.4. Project Cost Increase Comparison (Flyvbjerg et al. 2002)

Much research has been made into the factors that influence cost overrun, although a majority of cost overruns occur at the execution stage, many unforeseen factors are also neglected in the conception and design phases. Poor site management, inexperienced supervision, delayed decision, and constant change orders by the owners have been some of the most significant causes of cost over-runs in the construction phase of projects (Trost and Oberlender 2003;Iyer and Jha 2005). Ahiaga-Dagbui and Smith (2014) classified the sources of cost overruns into various factors such as risk and uncertainties, strategic misrepresentation and optimism bias (Flyvbjerg et al., 2002), scope creep (Love et al., 2012) and suspicious foul play and corruption (Flyvbjerg, 2009). Flyvbjerget al. (2004) investigated about 258 infrastructure projects such as rails, bridges, tunnels, and road works Denmark, the investigation highlighted that the three key factors affecting project cost are longer project implementation duration, project size and complexity, and public ownership factors. Kaming et al. (1997) analyzed factors affecting project cost in the construction of high-rise buildings in Indonesia, and noted that the weather conditions, materials cost escalation, inaccurate cost estimate, project complexity, and inexperienced contractors are the main causes for cost overruns.

Flyvbjerg (2008) further noted three possible cost overrun factors: technical, political-economic and psychological factors. Technical explanations are the most common cause of cost overrun (Flyvbjerg, 2009) and well known among project managers and estimators, technical factors relates to lack of management experience on the part of the estimators, imperfect forecasting methods, estimation mistakes, (Flyvbjerg et al., 2002; Flyvbjerg, 2005). Flyvbjerg et al. (2002, 2005) and Wachs (1990) attributed cost overruns in InPMps to political-economic and psychological factors. This factor explains that project owners and sponsors deliberately overestimate benefits with little estimate to the cost of construction so as to get the project funded. Psychological factors are associated with inaccurate estimates linked with psychology of optimism bias and planning fallacy

Project cost overrun has been linked to project complexities following the agreement and signed contract for the project, issues and disputes emanates following signing of the project. (Sovacool 2014). Unforeseen situations originate during the execution phase, and if not adequately resolved will typically lead to a cost increase due to cost required to resolve the issues. Design drawings, project size and scope, nature and location of project, disputes and miscommunication among the project stakeholder are project related uncertainties that affects the cost of projects. (Hoe, 2013). Complexities and complications in project design that later requires a different method and special equipment for construction may impact the cost of a project and difficulty accessing the project site which hinders mobilization and materials logistics are also project related factors leading to cost overrun.

Lack of professionalism by the contractor, consultant and client at the time of contract agreement could lead to cost overrun if the project budget is poorly managed at the tendering stage. Construction stakeholders approving the lowest bidder Awarding the lowest price tender are highly encouraged by the tendering system (procurement legislation), however, the price bid must be sensible and optimized by ensuring it fully covers the technical content of the project. Some contractors will go to all lengths (omitting the realistic figure that may cost the total project completion) just to win the tender without acknowledging the consequences of their actions by submitting the lowest bid

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**CHAPTER 3**

**ASSESSMENT AND INCIDENCE PRIORITIZATION OF RISK FACTORS IN PROJECT AND MEGAPROJECT LIFECYCLE**

**ABSTRACT**

1. **INTRODUCTION**

Infrastructure projects and megaprojects (InPMps) are crucial to economic activities, they support the growth of the society, embedded with complex design and construction processes, and known for their high project cost running into the millions and billions of dollars. InPMps are designed and developed to transform the structure of the society and often necessitates the government’s involvement due to their sheer size and impact on the society. InPMps are the framework for producing large-scale, complex, and a one-off capital investments in an array of public and private sectors ([Juliano](https://journals.sagepub.com/action/doSearch?target=default&ContribAuthorStored=Denicol%2C+Juliano) 2020), they take several years to complete and they often engage multiple stakeholders from the public and private sectors. Hirschman (1995) defined InPMps as the development process designed to ambitiously change the structure of a society while Oluwole (2018), stated that InPMps evolve as an indelible legacy of the people who dared enormous obstacles and the ambition to find solutions to complex problems of a sheer size. In a risk factor perspective, Zhai et al. (2009) identified that InPMps exhibits extreme complexity, substantial risks, long delivery timeline, have an extensive impact on the community, economy, technological development, and in the sited location

InPMps support the movement of people, goods and services, information and energy from the source, and due to their transformational effects, they support the policies of distance elimination by closing the gaps of special development. Numerous Infrastructure projects and megaprojects have enabled the remarkable changes in the global advancement of cities, environmental sustainability, power transmission, interconnectivity, internet of things (IoT) and success in the complex environment. The development of InPMps are the preconditions for industrialization and economic growth and in recent times, the demand, business case and development of InPMps are in high demand due to the growing global population. These initiatives are valid responses to the increasing populace. The world bank noted that Infrastructure projects boosts the activities of the agricultural and manufacturing sectors, and an investment in infrastructure projects support lives and aid poverty alleviation. Krugman, 1991; Holtz-Eakin & Lovely (1996) noted that InPMps such as seaports and airports fosters market integration and promotes domestic and international trade. Similarly, Reinnika and Svenson (2002), stated that the successful InPMps such as power generation facilities and reliable transportation network have positive influence on private and foreign direct investments (FDI) while the poor nature of these structures has detrimental effects on the private and foreign investments.

InPMps support the factors of production that contributes to economic growth; power aids production, educational facilities support human knowledge leading to a heathier living, and oil and gas structures strengthens the energy sectors (Calderon & Serven, 2014:5). The transportation network such as tunnels, highways and trains decrease the travel time by more than 40% (Wael and Chandra 2014) which ultimately improves workforce production time. InPMps also serve as the backbone for a rapid delivery of products and services. Ferreira, 1999 and Agenor & Neanidis, 2006 posits that the availability of a reliable telecommunication facility enhances more communication and eliminates time wastage among managers and workers. The inclusion of sustainable InPMps into the construction industry did not only prove that green infrastructure manages only stormwater, but it also provides other social, economic and environmental benefits not supplied by the gray infrastructure. Green InPMps have lesser project cost, consumes much more lower utilities (water, electricity and gas) and have higher return on investments (EPA, 2017). Green infrastructure prevents health issues, promotes healthy food, it reduces unemployment, and it maintains economic stability at the community level (EPA, 2017).

Despite their notable impact, Infrastructure projects are known for their cost overrun, time extension, quality issues and safety concerns, and they often fall short of the main project objectives. Edward 2011 concluded from a study of 300 global InPMps, that 65 percent of these projects failed to deliver their project goals. Many of the observed projects failed not only in cost overrun and schedule, but also failed to deliver the project’s products. Construction delays have contributed to the unaccomplished project ventures and a poor record of timely completion (NEDO, 1983). KPMG 2015, concluded from the survey that project failures in energy and natural resources have risen from 29 to 71 percent, public sector failed projects have risen from 10 to 90 percent, while projects in other fields have also risen 39 to about 61 percent. In the same report, a quarter of the surveyed InPMps were completed within 10 percent of the original deadline and one out of ten public projects finished on-time (Figure 1.0).

In response to the continuous reports of failed infrastructure projects, this research examines the risk factors affecting infrastructure projects, it investigates their correlation and prioritization in the project’s lifecycle. It assesses the occurrence of risk factors in each of project’s pre-planning phase, planning phase, construction phase and closeout phase. The research evaluates and ranks the highly impacting risk factors in each of the project’s phase. Using the Relative Importance Index, the risks factors were prioritized according to scale of occurrence and impact in each phase. The results and analysis of the research will provide a guide and enhance the knowledge of risk factors to be noted in each project phase, it will also present the required cognizant of project stakeholders to risk factors within the lifecycle/phases and the timely decisions be made to avoid cost overrun and extension of time on infrastructure projects.

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Figure 1.0: Projects that meets planned project cost. Source; KPMG International, 2015

**3.1 LITERATURE REVIEW**

**3.2 INFRASTRUCTURE PROJECT AND THE MEGAPROJECTS INDUSTRY**

Infrastructures are the lifeline of a nation, they are connected, and they form complex network (Bhattacharyya and Hastak. 2021). The InPMps environment has witnessed remarkable changes due to globalization and economic development. They have projects and megaprojects that supports the growth of a country’s GDP while their management requires an improved project management principles to avoid cost and schedule failure. A timely planning and detailed coordination of the infrastructure project sets the stage for the delivery of a successful infrastructure project. InPMps fulfill their requirements in many ways to meet the demand of the growing world, the challenges are that these projects often fail either with regard to budget or time or both. It is essential to acknowledge that developing InPMps is a critical and lifesaving endeavor that supports the complex environmental systems.

A larger portion of the Netherlands would have been submerged in the water but for the North Sea protection project, that has protected the low areas of the country. Sewage and water treatment projects protects individual from cholera and other health issues, while transportation and underground tunnels project provide faster reach to destinations. Big infrastructure projects are economically transformative; with more efficient transportation, the Panama Canal accounts for a significant GDP for the Panama, it contributes to the environment by reducing [GHG emissions](https://www.marineinsight.com/green-shipping/the-green-marine-environmental-program-a-general-overview/), it also reduces fuel consumption per cargo unit and lessen emissions than other means of transportation. The Atlanta Hartsfield-Jackson international airport retains its position as the world’s busiest airport. It is the pride of the Georgia state providing more than 63,000 employments and about $70 billion in GDP. The Hong Kong’s clean and speedy underground system has continuously supported the busy city. Estimating the growth in the infrastructure projects, McKinsey estimates that the world requires about $57 trillion on infrastructure by 2030 to enable global GDP growth, and of these, about two-thirds of these funds will be employed in the developing economy.

Infrastructure projects and megaprojects have achieved their initial and conceptual goals, and it is unlikely to think of a city without its infrastructure project or megaprojects. The Chunnel tunnel is synonymous with and connects France and the United Kingdom, the Boston big dig has tremendously reduced the travel time within the Boston city and the San Francisco Bay boast of its signature international orange golden gate bridge while Sydney in Australia is known for the most famous and 20th century Architecture masterpiece: the Sydney opera house. Despite their remarkable impact, InPMps are renowned for their cost overrun, schedule slippage, quality issues and safety concerns, and they often fall short of the main project objectives. They face uncertainty that emanate from human actions and interactions. They are threatened by insufficient situational awareness, higher expectations on returns rather than detailed planning and execution and utilizing a simplified approach to understand the complexity inherent in the execution of the InPMps. Often times, project costs and schedule are underestimated, and project benefits are overestimated. Flyvbjerg (2014) argues that project managers conceal cost information during the contract award stage until they face unavoidable challenges that reveals the real cost of the project. All too often, these risks and complications are not fully considered during initiation but a useful check for monitoring is the reference-class forecasting: to compare a similar completed project with the intending one. An instance is when a city intends to build a metro line, it should consider other cities with a similar project to ascertain an estimate required to complete the metro line.

Poor project execution and delivery has plagued the InPMps Industry and the contracting company are often tempted to reduce quality so as to increase their profit margins. Infrastructure projects and Megaprojects from design through planning to execution have been riddled with incomplete design, unclear project scope, and errors in scheduling and risk assessment. A McKinsey (2015) study shows that out of 48 infrastructure projects, poor execution was responsible for cost and time overruns in 73 percent of the examined project. Poor execution is a result of the complexity of the projects that a routine activity could become major construction hurdles. InPMps have been affected by low productivity. Construction productivity has remained in the decline. Wages have risen faster than inflation in many construction markets, resulting in higher costs of execution for similar project at different time.

**3.3 RISKS IN PROJECT AND MEGAPROJECT**

It is evident that projects and megaprojects are highly risky enterprises that involves cost overruns, time extension, and benefit shortfalls. The risk associated with InPMps have been constant and remained high for a 70-year period relative to the existing comparable data. Management of risks in InPMps are currently considered crucial and a mandatory part of delivering projects and megaprojects (Burcar et al, 2013). Risk management in the project and megaproject industry involves maximizing the results of positive events and reducing the effects of negative impacts on the project, and these practices shows the capacity of the stakeholders to effectively manage the risks with a positive influential outcome on the project. Malek, 2013 noted that risk management ultimately limits the project’s misfortunes and improves the probability that all project tasks are done within the stipulated timeline without a time extension and budget overrun. Risk and its management in InPMps are the proactive approach that present an assumed potential risk and the measures apparent to reducing the impact of the risks. It also involves all the aspect of the project such as the design, planning, execution, contracts and vendors, etc.

Due to optimism and project complexity, Denicol et al. 2020 argues that owners and engineers of projects and megaprojects will often underestimate cost and project schedules and overestimate the benefits to justify the needs of the project. Project managers competes to win a contract and as such conceal some construction data until the realization of the real unpalatable construction processes which could present a fast track to failure. Risk emanates in construction projects when cost and schedules are poorly analyzed, these inadequacies result in time extension and relatively a cost addition due to administrative overheads. Inadequate design and substandard engineering works are results of overoptimism leading to reworks and benefit shortfalls in projects and megaprojects. A reality check against such megaproject failure is to assess the project with similar completed projects known as reference-class forecasting. The forecasting method confirms the bias by forcing project stakeholders to consider procedures within the project estimates that does not justify the anticipated project.

Poor execution of works tops the list of risk issues within the InPMp sector. The risk of executing a poor project is synonymous to cutting corners by the contractors to sustain project cost assumptions and protect a slim profit. Poor execution is also a result of the experience supervision by the engineering/consulting firms. It emanates from several risks issues and results in cost overrun from rework and additional time to fix the rework. This aspect of risk associated with project and megaproject is riddled with incomplete design, unclear project, scheduling and an overall incomplete risks assessment method. McKinsey. (2015), reported that out of 48 failed megaprojects, risks associated with poor execution led to cost and time overruns in 73 percent of the cases. Poor project execution will continue as long as project and megaproject remain complex without a granular process of execution and the small routine tasks become a major roadblock to completion. The Inadequate definition of the roles project requirements of key stakeholders such as owners, clients, and operators are leading cause of risk in projects and megaprojects. Project scope definition and requirement documentation form the foundation which other project task such as cost, schedule, quality, and safety rely upon. Poor performance and failure in the execution of InPMps will be reduced when the roles and scope requirements are listed and recurrently verified during the execution.

Projects and megaprojects fail due to the introduction of unproven technology leading to cost and time overruns. The uncertainty about technological innovation often led to delayed design time, operational and personal approval for the technological use. This is a leading risk in InPMps emanating from the unproven technology to address difficult construction works subsequently leading to delays. The capabilities of the project stakeholders determine the success of most InPMPs. Several Large projects are either sponsored by entrepreneurs or by the government. Government financed project tend to finish within the planned period with few exceptional large projects while many projects fail due to the financial and technological capacity beyond the individuals or entrepreneurs. Stakeholders’ capacity connects with the inability to assemble competent and experienced personnel to meet the project requirements at different project phases, this however impacts all aspect of the project delivery: from design, planning, execution to commissioning.

The construction supply chain affects the operations of project and megaprojects. The larger network of construction supply and vendors integrates the aspects of program management, vendor relationships, and systems integration. The management of systems and procedures, and the means to control, monitor, optimize and consolidate the benefits from individual inter-related projects form the program management. Program management pose a risk to the projects from the inability to obtain the adequate information and lack of proper coordination of projects and subprojects at the various phases of the project life cycle. Vendor relationships establishes the appropriate interfaces within the participating organizations and the management of the interfaces through the entire project phase. The leading vendor relationship risks that affect projects and megaprojects is the inadequate understanding of interdependencies associated with vendors during the life cycle. These impacts the InPMps at different levels such as the inter-organizational, intraorganizational, and external environments. Systems integration is the managerial and technical ability to integrate all construction project parts produced by the different organizations into a cohesive whole. System integration in InPMps becomes a risk through the inadequate knowledge of overall project architecture and business objectives. The system integration across the project including the program management is prone to disaster when the architecture and objectives are not disseminated across board.

The failure, success, and performance of projects and megaprojects should be an element of the objectives of the system architecture and overall delivery framework. A more realistic approach to managing and improving the delivery of InPMPs is to observe and note their consequences of failure. Projects and megaprojects are currently so huge and consequential to most individual, entrepreneurs and agencies that time extension, cost overruns, benefit shortfalls, and poorly managed risks may ruin businesses and corporations, and nations GDP may be affected by a single megaproject failure

**3.4 RISKS FACTORS AND CATEGORIZATION IN PROJECT AND MEGAPROJECT**

A key factor to the success of InPMps is an effective risk management process that considers all forms of risk originating point and their respective impact. This is predominantly new in the management of risk in the construction sector. InPMps have several risk features such as the time constraints, cost overrun, stakeholders’ requirements, project objectives, financial limitations and organizational policies. In large projects and megaprojects, risks are the foremost variable that has continuously impacted the success of their construction, and the management of these risks are paramount to any capital project (Krane et al., 2010). Risk management should analyze risks and categorize them based on their source and impacts. Patrick X.W. Zou et al., 2007 categorizes the risk as per its implication and importance along with the relative objective of the project such as scope, quality, time, safety and environmental impact. Patrick X.W. Zou et al., 2007 infers that the construction task must be the responsibility of the stakeholders for the purpose of rectifying imminent risks.

Siraj and Fayek (2019), identified and placed project risks into unique categories. They concluded that due to the method of identifying and analyzing 571 risk factors, risks factors fall into different several categories as shown in table 3.2 Risks factors are categorized depending on their nature, occurrence, source, impact on project objectives, the risks originator and the multi-level classification method (macro, market and project level), Hastak and Shaked (2000). An obvious method for risk categorization is to sort the risks factors into groups based on common features, and they are categorized based on technical, contract and organizational areas. Risks categorization maybe based on organizational tradition and operational purpose in order to reduce the risks, Hillson (2004), or they maybe also be grouped based on their impact on stakeholders and project scope. Al-Sabah et al.(2014), El-Sayegh and Mansour (2015), and Tah and Carr (2000) categorized risks factors into internal risks (project-related risks that fall under the control of the project team) and external risks (risks that falls beyond the control of the project team members). These risks were further classified into subcategories based on their nature and type of the projects.

The nature of risks was also used for categorization by Boateng et al. (2012), Elbarkouky et al. (2016), and Tavakolan and Etemadinia (2017). Tavakolan and Etemadinia (2017) categorized risks into financial, contractual, design, health and safety, management, construction, social/political, external, and procurement/supply risks. Furthermore, Goh et al. (2013), Lee and Schaufelberger (2014), and Li and Zou (2011) also categorized risks with respect to project stage into planning and design, procurement, construction, and completion/handover risks. Equally, Zou et al. (2007) categorized risks based on the impact on the project such as cost overrun, time extension, quality issues ,environment and safety-related risks. However, these categorizations may result in redundancy: a result of a single risk impacting more than one project objective. Wang and Yuan (2016) further categorized risks into five groups: client, designer/engineer, contractor, subcontractor, and government related risks. Categorizing risks factors could be based on project finance, team managerial ability, technical and construction issues, project stakeholders, environmental and force majeure, legal and economy (Alashwal and Al-Shabahi, 02018) and four of these categories: construction, physical, estimators and financial were validated by Eliufoo (2018). Oyedele (2015) did a review of the risk management and its categories in the Nigerian construction industry and identified thirteen risk categories: economic, legal, political, security, government policy, year of the project, detail of brief, corruption, time, location, project complexity, management experience, and project sector. Figure 2.1 shows the comparison between risk Categorization and risk factors.

Graphical user interface

Description automatically generated with medium confidenceTable 3.2 Identified Risks Factor. Siraj and Fayek (2019)

Hastak and Shaked (2000), summarized a list of project risks into the macro, market and project level, and this was corroborated by Bing et al. (2005) and Hwang et al. (2013). They also categorization risks into three-level meta-categorization; macro-level risks (risks beyond the system boundaries of the project), meso-level risks (risks within the system boundaries of the project and directly related to the nature of the project), and micro-level risks (project party-related that are associated with the parties involved in the project). Bruzelius, Flyvbjerg, and Rothengatter (2002) risks categorization distinguishes between: cost risk (construction, maintenance, and operation), demand risk (traffic forecast, and revenues) financial market risk ( future interest rates) and political risk (regulation, parallel public investment, and pricing in adjacent parts of the network. Project and Megaproject’s risks factors have been widely categorized based on their source or nature and categorizing them varies by the type of projects, procurement type, and the project team analyzing the risks factors.

Regardless of source, nature, the project team and other forms of risks factor categorization, project risks are structured and presented using the risk breakdown structure (RBS). This research aims at establishing and analyzing the behavior of 32 risk factors in the project lifecycle of InPMps. The 32 risks factors were part of the 73 factors analyzed by Hastak and Shaked (2000) and their assessment will present the knowledge for planning and the proactive management of risk factors throughout the project lifecycle. Figure 3.1 shows the summary of identified risk factors and their categories; Political risks, Cost/Economic/Financial risks, Planning and Design risks, Construction Execution, Operation, Quality and Safety risks, , Technology risks, Contract and Legal risks, Resources risks, Business/Cultural risks, Market Potential risks, Design, construction and Quality risks.

***Political Risks (Pr):*** Ashley & Bonner (1987) explained that the interference of government with construction operations are forms of political risks. Howell and Chaddick (1994), describes political risks as those social events that are likely to influence construction environment and international expansion. (Mortanges and Allers, 1996), also explains that political risks relate to the political activities, government intervention within (Zhuang et al., 1998) that endangers construction success. Ling and Hoi, (2006) stated that political risks are difficult to mitigate due to their unpredictability nature and studies on these risks factors have revealed their identification and management relative to foreign direct investments and international joint ventures. The political unrest may not influence the construction business but may impact the construction market (Hastak and Shaked, 2000). Political risks are results of changes to government regulations and policies which cascades an impact on the project objectives.

***Cost, Economic & Financial Risks (ECF):*** these are economic and financial uncertainties that do not support construction success. These risks are likely to emanate from economic and financial crises such as underdevelopment, exchange rate, reserves, inflations and fluctuating prices of construction materials. Other uncertainties that might affect construction operations are high interest rates, inaccurate project estimate. Stakeholder capacity to finance the project. De Neufville et al. (1977) recommended a contract model that considers the condition of the economy and Warszawski (1981) also advised the inflation status to be considered during project cost estimates. A dynamic laws and regulations, safety rules, insecurity, civil disorder, and communication barriers are forms of economic and financial risks. ECF risks are linked with financing and the financial framework of the projects and megaprojects, the financial components such as the anticipated profitability of the projects and megaprojects

***Planning & Design Risks (PD):*** Planning and design risks factorsare associated with feasibility studies, pre-planning and planning stages of the construction process. Some of these uncertainties are due to unclear project scope and specifications, and vague design details. Planning and design risks causes delays to schedule resulting from unforeseen ground conditions, inefficient team communication, and coordination with the locals. McManus et al (1996) evaluated risks in architectural projects and concluded that delays in the planning and design phase included inadequate schedule control by the engineers, inaccurate scope review, ineffective project planning and coordination.

***Construction Execution, Operation, Safety, & Quality Risks (CEOS):***  These are usually the most significant risk in associated with the projects and megaprojects Cost overruns, time extensions, lack of proper coordination, and accident are classified under these types of risks. The Incompetence on the part of the construction/project manager possess a threat to the construction project, and if not adequately evaluated will further cascade more damages to the project. These risks factors are associated with project execution, materials logistics, engineering and procurement processes. Hastak, M. and Shaked, A. (2000) also noted that bad quality of material and bad completed works is associated with construction and quality risks. Construction risks are often associated with incomplete design, change of scope, insufficient resources, inadequate specifications, scarce construction materials, productivity of labor, equipment and site conditions, quality standards. Construction and execution risks are generally present through the entire lifecycle of project and megaprojects, they comprise of project scheme, cost upsurge, unsuitable designs and mishaps during construction.

***Contracts & Legal Risks:***  Most legal and contract risks that affects construction projects are inadequate legal framework that imposes legal ruling, inadequate joint venture contract terms, and lack of well-defined codes and building laws. Zhuang et al. (1998), stated that regular changes to rules and regulations governing a regions construction process present uncertainties to the construction industry. Shen et al. (2001) concluded that increase in construction materials is a result of legal and contractual policy changes.

***Resources & Technology Risks:*** Unavailable skilled and skilled workers are likely to affect the schedule and cost of a project. In addition, scarce construction equipment, delayed construction materials, unavailability of required technology for construction processes are risks associated the resources and technology.

***Health & Environment Risks:*** Construction site are prone to outbreaks of disease and infections, and the event and effect of epidemic is a major set-back for project success. Another set of health and environment risks are natural disasters such as flood, hurricane, tornado and earthquake. Environmental risks manifests in several dimensions in the project lifecycle and may cause significant issues at every project phase. These risks also include public interest demonstrations from the pre-construction stage through construction to operation and maintenance process in the post-construction stage.

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Figure 3.1 Risk Categorization and Risk Factors.

**3.5 PROJECT RISKS MANAGEMENT AND ANALYSIS FRAMEWORK**

Managing risks on InPMps identifies, assesses, and responds to factors that will and impacts the successful delivery of the projects. Risks factors are common scenarios in InPMps, they have consistently caused delays and failures to project execution and risks management is vital to tackling these failures. The risks management processes have been a greater relevance to the InPMP industry, it is a conceptualized method of assessment, and their introduction and methods addresses the impacts of risks on projects and megaprojects. Despite other methods of addressing project failure, risks management remains an accurate and significant approach to still represent the foundation of managing a successful project in the InPMps industry. Every stage within these processes should be included to address the risks and adequately employ all phases of the project.

High risk impact and their significant effects are defining properties of InPMps, hence, an effective risk management is imperative for the development and a benefit to the industry. The risk management method is not a recent development only in the construction industry, but it has been applied in facets requiring an analyses, assessment and decision from a risky condition with essentially uncertain results. However, its implementation as an acceptable analytical procedure that has been applied to the management of InPMps issues and it has been a recognized tool for appropriate decision making. It examines the integration of risky policies, the formation of risk cognizance, and through risk management, clarity increases, project issues can be lessened from the outset by been proactive and projects are properly planned for execution. By this method, impacts and consequences are mitigated and the project manager holds the full control over the project.

Managing risks in InPMps has gathered international recognition due to the numerous and extensively conducted research. Despite this, the risk management methodology requires more attention and derivative benefits to the construction industry. Project scope and products are unique to individual projects, as such, the risk management methodology should address only the scope and complexity of the individual projects. Conducting a risk management process for the InPMps could be quite challenging and two types of risk management procedures have been considered while managing risks on InPMps. The preventive techniques allows the management of risks before the project starts, it assesses the predicted risks factors during the construction and closeout of the project, while the remedial techniques evaluates the impacts of a risk after it has occurred. Risks initiates from various sources and impacts phases of the InPMps at various time. These risks and their causes should be drawn along with the respective impacts, and the planned accordingly for according rectification. Risk management does not measure the success of a project, but it is a process that enhances the success of InPMps; hence a proactive and not a reactive tool. Risk management acknowledges the concept of uncertainties such as opportunities and threats in an InPMps development. It formally addresses risks and it is indistinguishable from an overall project management perspective. A key benefit of risk management also involves its aim at dealing with available ambiguities within the project’s life cycle. The objective is to achieve a proper balance between the risks, but not accepting a risk over the other. Risk management includes the assessment framework of identifying, assessing risks possibilities and impacts, planning for strategies, assessing their state, and maintaining an awareness of threats to project success.

Risks management entails stabilizing the various project risks concerns, impact on metrics and the overall wellness of the project. It reflects on various alternatives, assess their strength and weakness and makes best favorable decision for the project. Risk management should be a properly established procedure with an available data and a clear purpose of use. Probabilistic and statistical methods have been employed to provide effective support and decision for managing risk occurrences and impacts on InPMps. However, the decisions on risk factors are to an escalating amount, due to the characterized events of uncertainties and emergence. The uncertain events requires different types of methodologies and this has been a challenge to the risk field to develop suitable frameworks and tools for this purpose ([SRA, 2015b](https://www.sciencedirect.com/science/article/pii/S0377221715011479#bib0131)). The risk management framework comprises of risk Identification, assessment and Risk assessments are employed should be made of each risk's potential impacts to planned capabilities, and whether they have collateral effects on dependent capabilities or technologies.

Risk identification is the process of systematically and continu-ously identifying possible risks and their potential consequenceson a project using different risk identification tools and techniques,classifying the risks into different categories, identifying their rootcauses, and documenting the characteristics of each risk

Gray and Larson (2011)  defined risk as the possibility that an unwanted occurrence will occur, as well as the impacts from known scenarios. However, project risks are not easily assessed because the rate of occurrence and their impact are not usually easily quantifiable. As a result, project risk may be assessed and quantified approximately through statistical means and must be itemized hierarchically for a complete identification and assessment. Risks identification begins with the detailed knowledge of the project’s requirements and objectives prior to the identification processes. And it is crucial to identify a large range of risk factors, as a left-out risk factor might emanate along the project lifecycle. The result of a comprehensive risk identification is checklist. Chapman (2001) highlighted some methods for identifying project risks and uncertainty of events during project execution. These methods include Brainstorming, Delphi Technique, Checklist, Expert Opinions/Structure Interview, and historical data

* **Brainstorming (BS)**: In a risk identification process, brainstorming is an ideal technique for generating ideas and assumptions of likely and unlikely events. It entails a group been led by a facilitator, seeking suggestions and mapping the possibilities of risks factor occurrences. BS as a technique, promotes the creativity of solving problem by sharing ideas and thought process among the participating groups (Gogus, 2012). Brainstorming has been employed extensively in the identification and itemization of likely project risks, and it has been expanded to other areas of management for opinions, explanations and solutions. During the BS session, participants ability for generating ideas are quantified based on the uniqueness of opinions ([Fu et al., 2015](https://www.sciencedirect.com/science/article/pii/S1871187117302729#bib0120)), and these quantification is assessed relative to the solutions delivered by the group or participants. The distinctiveness of ideas, is evaluated estimated based on the dimensions related to novelty, workability, relevance, and specificity of ideas ([Hong & Chiu, 2016](https://www.sciencedirect.com/science/article/pii/S1871187117302729#bib0160)).
* **Delphi Technique (DT):** More than a traditional tool, the DT method has been embraced for uses beyond predictive purposes, becoming widely used as a tool to aid decision making by gathering expert opinion (Gupta and Clarke 1994;  Rowe and Wright 1999; Landeta 2006) This technique is quite similar to brainstorming session, but the participants in this risk identification process are not co-located and they do not know each other. In a consensus where opinions from experts in different locations are gathered to determine prioritization and predict trends/patterns, the Delphi technique is best employed. The DT method is iterative, often with participants expressing their thoughts and opinions severally about certain philosophy or assertions of a project risk in Likert Scale survey procedure. Experts within the construction industry are selected to participate in the DT process and an amount of knowledge in the construction sector is presupposed with these experts. The several rounds of assessing the views and thought of participants presents a further understanding of risk identification in risk management.
* **Checklists (CL):** These are common methods in the management of risks in the construction sector [Pinto et al. (2011)](https://www.sciencedirect.com/science/article/pii/S092575351731559X#b0190). They are simple but very useful predetermined lists of factors that are possible for the project. The checklist containing the list of managed risk from a past project and the response methods to those risks improves the appropriate method of identifying similar risks in the current proposed project. This tool enables the creation of features of risks factors presumed to occur, and it is also used as a control tool prior to risk evaluation and decision making in Infrastructure project. Checklists are highly effective procedure by which the accuracy and efficiency of risk identification depends on and a list of solutions are drawn along with the identified risks during the risk identification.
* **Expert Opinion/Structured Interview**: Project team members with an expertise within the construction industry can be engaged in an interview or opinion session for risk identification. These methods of risk identification reduce the assessment time, and provides an informative list of likely risks that might occur on a similar project previous involved in. All project team members or stakeholders relevant to the project can be interviewed during the risk identification process.
* **Historical Data:** History and the analogy of risk occurrence and its management from past projects can be adopted during the identification of risk on another similar project. These methods have been utilized for risk identification and assessment to predict the present state and potential future impact of risk on projects. Employing historical data to risk identification helps to define how a project metric might behave when such risk finally occurs on the project. It also identifies the risk requiring more attention and that worth accepting and mitigating. Experts should interpret the data and apply the appropriate perspective of risk management as a crucial step while using historical data.

**Risk Assessment Framework**

The intent of a risk assessment is to assess and quantify the impact of identified risks on a project. It evaluates and measures the probabilities of a risk occurrence and its probable level of impacts if they occur. Risks assessment enables the project team to decide which risk or project phase need an additional resource to lessen the impact from risks. The assessment process provides a crucial decision in the development of InPMps, it also presents details of points in the lifecycle of the project requiring more resources to manage or mitigate the probability of effect. In order to successfully manage the assessment of risks on construction projects, Shen et al (2001) established a risk significant index, some of these risk indexes were also identified by Wang and Liu (2011) as ‘low, medium and high’. These represented the level of risk impact as low, medium and high risks. KAU 2010, also recognized a significant index used to quantify the ranking of the risk factors and the ranking of the effects related to these risk factors.

Studies have investigated risk assessment in the construction industry, and each research with its viewpoints. (El-Sayegh, 2008) investigated the risk assessment on the economy and impact relative to Inflation and sudden changes in prices, sociopolitical risk assessment by (Ling and Hoi, 2006), business risk assessment (Wang et al., 2008; Deng et al., 2014), and occupational risk assessment by Pinto et al., 2011. These studies presented the significant understandings of the macro-level risk assessment in the InPMps industry. Analyzing the causes and impact of risk is a significant process in the construction industry, and if not adequately assessed, it could result in the disruption of project metrics and an unhealthy construction industry. Risk assessment is performed by quantitative and qualitative methods

**Quantitative Risk Assessment (QRA):** This is a systematic risk analysis of quantifying risks related to the construction process, it identifies the possible hazards/threats, examines the probable cause and presents the consequences of the risk on a construction project. It answers the questions: what might go wrong, how possible is it to go wrong, and what are the likely impact if the something goes wrong. This is also the process of statistically evaluating the impact of identified risk on the overall project objectives( PMBOK 2011). Quantitative Risk Analysis is performed on already ranked, noting the effect of each ranked risk and assigning numerical rating to the risks. In the QRA, the single impact of the risk factors is not considered, but it analyses the impacts on the overall project. Methods of quantitative risks assessment includes:

* **Sensitivity Analysis**: Sensitivity analysis of risk models identifies the most important risk factors, the effects and priorities the steps for mitigating the risks. This is performed to ascertain the project risk factors likely to have maximum disruption or effect on the delivery of project. [Baker et al. (1999)](https://onlinelibrary.wiley.com/doi/full/10.1111/0272-4332.00039#b5) noted this method as one of the primary risk quantitative tools applied in risk management. In risk assessment, the sensitivity analysis verifies the sensitivity of different risks impacts on project success. [Jones (2000)](https://onlinelibrary.wiley.com/doi/full/10.1111/0272-4332.00039#b68) suggested that sensitivity analysis provides the basis for project planning measures to lessen the impact of project risks, it also helps to assess uncertainties for the purpose of prioritizing additional impacts of risk on project (Cullen and Frey, 1999). Sensitivity analysis as a risk assessment method has been applied in the risk analysis of engineering systems, physics, economics, medicals, and social sciences decision-making process. ([Oh and Yang, 2000](https://onlinelibrary.wiley.com/doi/full/10.1111/0272-4332.00039#b106); [Baniotopoulos, 1991](https://onlinelibrary.wiley.com/doi/full/10.1111/0272-4332.00039" \l "b6); [Helton and Breeding, 1993](https://onlinelibrary.wiley.com/doi/full/10.1111/0272-4332.00039#b57); [Cheng, 1991](https://onlinelibrary.wiley.com/doi/full/10.1111/0272-4332.00039#b23)).
* **Scenario Analysis:** The scenario analysis focuses more on the risk factor with the greatest impacts on project and develops the alternatives for operations and how the likely high risks will influence the success of the operation. This foresight-structured procedure helps the project teams make strategic preferences about where and how to assess the impending risks, its impact and where to direct its mitigation plans. Mulvey and Erkan ([2003](https://onlinelibrary.wiley.com/doi/full/10.1111/j.1539-6975.2012.01506.x#jori1506-bib-0017)) illustrated that when scenario analysis is adequately used, it reveals many important aspects of a risk factor situation that would have been omitted. Scenario analysis for risk assessment must be done within a time frame, otherwise, it will render the analysis obsolete. The Scenario analysis simulates the likely occurrence of all categories of risk based on certain notions (López-Baldovin et al. [2006](https://link.springer.com/article/10.1007/s12145-020-00518-w#ref-CR11)). A scenario-analysis-based risk-assessment methods can intuitively and precisely suggest the extent of the impact from risks and the affected scope, this can accurately present the distribution pattern of the risk impacts.
* **Monte Carlo Simulation:** This method examines the [permutations](https://www.sciencedirect.com/topics/mathematics/permutation) of uncertainties and risk occurrences in a project. Firstly, the appropriate distribution function is determined for each uncertain risk and further analyzed in the second phase of risk assessment process. This method may be applied to project schedules to evaluate probability of completing the project within the target completion date. Project manager and risk experts allocates a probability distribution function of duration to each work task or work packages within the project to achieve an accurate evaluation of the risk assessment. The distribution function entails a three-point estimate of most-likely, worst-case, and best-case scenarios. These estimates are then simulated, and after simulation, project team can report the individual probability of risk impact on the project. [Smith (1994)](https://link.springer.com/article/10.1057/palgrave.rm.8250017#ref-CR28) outlined how Monte Carlo simulation assists managers in choosing from different potential investments and projects, it is also used to understand the behavior of risks on construction projects; [Gilchrist et al (2003)](https://link.springer.com/article/10.1057/palgrave.rm.8250017#ref-CR11) developed a the simulation model that permits contractors to calculate, mitigate the existence, and reduce the impact of construction noise on their projects. This model was tested and validated using field measurements during various stages of the construction of an eight-story parking garage in London, Ontario, Canada

**Qualitative Risk Assessment:** Compared to the quantitative risk models where likelihoods of risks are measured quantitatively, the qualitative risk assessment approach utilizes a subjective risk measurement to describe the probability of the risk factors. Qualitative risk assessments present an estimated interpretation of results if little or no data exists, and they are easily understood by the project stakeholders. ([Gravenor and Kao, 2003](https://www.sciencedirect.com/science/article/pii/S0167587711000055#bib0050), [Heim et al., 2006](https://www.sciencedirect.com/science/article/pii/S0167587711000055#bib0060)). Qualitative risk method is a subjective approach of assessing risk, it measures the likelihood of risk occurrence and the level of impact of the risk. The main purpose of this method is to ascertain severity of occurrence and impact and the results are documented in the risk assessment matrix (Figure 2.2) mainly to report potential hazards on the project. Qualitative risk assessment can be analyzed with the following methods:

Chart, table

Description automatically generated

Figure 2.2 Risk Assessment Matrix Table. ***Source; https://www.safran.com***

* **Risk probability and impact assessment:** The application of the risk and impact assessment method evaluates the likelihood of occurrence of an uncertainty and its impact. The effect of risk project is measured relative to its positive consequences for opportunities, and the negative effects which result from threats. In risk assessment, probability and impact should be tailored to a single and unique project, this will enable a clear definition of scale of assessment and should be drawn up within the project scope. In the probability and impact assessment matrix, PMI (Project Management Institute) noted the risk probability range from '*very unlikely*' to *'almost certain’*; and the numerical measurement of impact scales from '*very low*' to '*very high*'.
* **Probability/impact risk rating matrix:** The Probability and impact assessment method are base for the quantitative analysis. The scale of prioritized score, the rating and color coding are assigned to the importance of each risk occurrence and impact. Threats indicating an higher impact and possibility are classified as high-risk and requires urgent attention, while lower score risks can be monitored and checked for possible spike and impact on the project.
* **Risk categorization and Risk Urgency Assessment**: Risk categorization classifies each likely threats to the projects. It helps to identify section of the project been exposed to threats and requires urgent attention. The work breakdown structure (WBS) and Risk breakdown structure (RBS) are crucial tools for achieving these assessment models. They help to develop the appropriate risk response at any point in the project lifecycle.

**3.6 Project Lifecycle and Risks and Assessment Nodes**

**3.7 Research Methodology**

**3.8 Risks Prioritization in Project and Megaprojects**

**3.9 Results and Discussion**

**3.10 Research Benefit**

**3.11 Conclusion**

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**CHAPTER 4**

**ASSESSMENT OF RISK FACTORS AND THEIR CASCADING IMPACT ON THE PROJECT LIFECYCLE INCLUDING MEGAPROJECTS**

Abstract

4.0 Introduction

4.1 Literature review

4.2 Risks Assessment Process

4.2 Risks Factors and the Project and Megaproject Industry

4.3 Project and Megaproject Lifecycle

4.4 Risk Factors and Project Lifecycle

4.5 Relational Assessment of Project Metrics and Risk Factors

4.8 Research Methodology

4.9 Data Analysis

4.10 Results and Discussion

4.11 Research Benefit

4.12 Conclusion