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Project Risk Management for Sustainable Restoration of Immovable Cultural Heritage: Lessons from Construction Industry and Formulation of a Customized PRM Model

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DEDICATION

This dissertation and my entire PhD are devotedly and affectionately dedicated to my late father, Dr. Abiduddin THAHEEM, and my mother. The dreams they envisioned and the toil they put in for realizing those dreams, all the while maintaining the most of humble and appreciative demeanor, have always been an unwavering source of inspiration and determination for me.

I also dedicate to my loving wife, Dr. Tehsin Qadir. The never-ending motivation and drive contributed by her are equally responsible for where I stand today.

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LIST OF ABBREVIATIONS

AHP	=	Analytic Hierarchy Process
ANSI	=	American National Standards Institute
ANOVA	=	Analysis of Variances
ANP	=	Analytic Network Process
APM	=	Association for Project Management
AS	=	Australian Standard
CEM	=	Construction Engineering and Management
CM	=	Construction Management
CMMI	=	Capability Maturity Model Integration
EMV	=	Expected Monetary Value
EPC	=	Engineering Procurement Construction
EVA	=	Earned Value Analysis
EVM	=	Earned Value Management
ICT	=	Information and Communication Technologies
ISO	=	International Organization for Standardization
M_o_R	=	Management of Risk
NZS	=	New Zealand Standard
OBS	=	Organizational Breakdown Structure
OPM3	=	Organizational Project Management Maturity Model
PI	=	Probability - Impact
PI Matrix	=	Probability Impact Matrix
PM	=	Project Management
PMBOK	=	Project Management Body Of Knowledge
PMI	=	Project Management Institute

PMO	=	Project Management Office
PMP	=	Project Management Professional
PRAM	=	Project Risk Analysis and Management
PRINCE2	=	PRojects IN Controlled Environment, version 2
PRM	=	Project Risk Management
RBS	=	Risk Breakdown Structure
RM	=	Risk Management
WBS	=	Work Breakdown Structure

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ABSTRACT

The purpose of this research is to introduce and develop a knowledge base for restoration industry aimed at understanding and dealing with risks arising in restoration projects of built and architectural cultural heritage. These projects face a number of risks and are viewed unfavorably from a number of sustainability perspectives. The research study, therefore, is expected to generate interest and debate among the professional and researcher community in the arena of restoration of built cultural heritage for formally applying Project Management (PM) and Project Risk management (PRM) theories and practices.

The research method consists of reviewing published literature and analyzing the dynamics of restoration industry (both from academic and practitioner point of view) in order to propose an application framework. Owing to a number of striking similarities between construction and restoration projects (and more so with building renovation and maintenance), an attempt is made in order to align this study nearest to the construction sector, incorporating the lessons learnt in that area. Building upon and taking inspiration from the fundamentals of Construction Management, this thesis proposes a framework which is supposed to methodically apply risk management within the proposed project management stages.

Research results seem to have confirmed that the restoration industry has not yet exposed to formal PM and PRM theories and practices to a greater level. Thus there is enormous impetus and ensuing incentive with the incorporation of formal theories and customized tools as proposed by this research, which attempts to target the exceedingly important area of cultural heritage restoration and the missing aspect of PM and PRM. Further, the proposed framework is an attempt at bridging communication gaps between management and restoration experts. Thus, it highlights the importance of scientifically and effectively managing restoration projects. Nevertheless, this uniting attempt has its own risks in terms of terminologies, technical language, and the understanding of risk and its management which may be a practical limitations as in the field of engineering also, the foundation of PM and PRM areas of knowledge finds its traces in Construction Management – which is further an application of management in construction engineering - it's rather challenging to reconcile knowledge from different areas.

Further, the study explores issues concerning sustainability of restoration projects based on their use of PM and PRM. Results are expected to help stakeholders of restoration projects understand and apply the proposed PRM framework. This study is also aimed at developing a foundation for dissemination of PM and PRM knowledge in restoration industry, and provides impetus for future studies to examine how restoration projects can deal with risky situations.

Based on the emphasis on sustainable development aspects of restoration projects for facilitating the stakeholders of built cultural heritage in taking critical decisions (because if not managed properly, the risks in a restoration project may either cause project failure or damage the historical buildings), it can be stated that this study has some potential sustainability implications. Therefore, from society's sustainability perspective, it is imperative that stakeholders identify, analyze, control and manage risks before commencing the restoration activities.

The study is an original effort in examining the penetration of PM and PRM practices in restoration industry. Based on it, the study proposes an original framework for application of formal PRM for restoration projects. Results are of relevance in today's world where risks hinder and sustainability guides the decision making.

PREFACE

Cultural heritage, which may literally translate into 'inheritance of culture', is a complex combination of legacy and tradition of a society and civilization continued and fetched into present. The word 'culture', as defined by Tylor (1871), "*is that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society*". Another definition of the term by Encyclopedia Britannica is "*the integrated pattern of human knowledge, belief, and behavior".* Implicitly, it can be deduced from the definitions that culture is something which may not be genetically transmitted from one generation to the other but learned. The architectural heritage is the long-term memory of society; it is the reflection of the past which will be carried into the future.

However, if the culture is not transmitted directly, what should its heritage considered to be, if not the culture itself? It is not so easy to differentiate between "*culture*" and "*cultural heritage*" since former is by definition not inherited – but only learned and adopted (Buckland, 1997). Without getting much into this philosophical debate, it can be deduced that the term "*cultural heritage*" may encompass three concepts:

1. It may imply the ways using which the cultural knowledge is transmitted.
2. The notion of "*culture*" deals within the contemporary, therefore cultural heritage is historical.
3. Finally, it may signify the artifacts pertaining to historical times.

Taking forward the last characterization of cultural heritage, it may broadly be defined as consisting of movable and immovable, tangible and intangible heritage with strong historic, artistic, scientific, social, economic and cultural values of identity (Jokilehto, 2005). The tangible-immovable cultural heritage is present in the form of edifices, monuments, castles and various other buildings. These structures are at the core of human ingenuity from past eras. They act as bridge between humans of today and their forefathers who lived and constructed the built environment of their day centuries ago. The importance of these buildings cannot be overstated for any society who takes pride in their past. But the drive towards globalization has turned every nation into the custodians of centuries old structures owing to the concept of common heritage of mankind.

"*Declaration on the Responsibilities of the Present Generations Towards Future Generations*" by UNESCO explicitly takes into account the importance of this shared notion of responsibility of present generations to safeguard and protect the immovable cultural heritage artifacts and buildings (UNESCO, 1997). The Article-7 of the declaration mentions that *"with due respect for human rights and fundamental freedoms, the present generations should take care to preserve the cultural diversity of humankind. The* *present generations have the responsibility to identify, protect and safeguard the tangible and intangible cultural heritage and to transmit this common heritage to future generations"*. In purview of this declaration, the significance of preserving cultural heritage gets more pronounced and vivid.

Notwithstanding, the growing importance of cultural heritage may however be challenged: why a nation, a society or a group of enthusiasts are burdened and bothered with such a daunting task of preserving old and rotten structures? Why not invest all the resources in building new and modern structures which can actually add value, withstand the modern challenges and serve the purpose? Undoubtedly the rejoinder is simple: these buildings are the manifestations of creativity, skill and innovativeness of their times. They represent the culture of area where they are geographically located and thus help build and shape an identity for dwellers and citizens of their host places (Gupta and Ferguson, 1992). Further, since culture is associated to national and societal pride and honor (Pullar, 1992), these buildings – due to representing and manifesting culture – are a source of pride for their host nation and community, and their internal cohesion (Bedate et al., 2004).

Such expressions of cultural pride and communal consistency demand preservation, protection and safeguard at all possible costs. However, the World Heritage properties are exposed to natural and man-made disasters; they are continuously and increasingly challenged by risks which are less natural in their dynamics, if not in their cause. The list goes on from floods, mudslides, landslides, coastal erosion, fire, earthquakes and manmade hazards such as civil unrest, industrialization, chemical waste, etc. This results in threatening the integrity of these buildings and structures, and may even compromise their values (UNESCO, 2000). The damage and deterioration of these outstanding properties are capable enough to have adverse effects on the local and national communities, both for their cultural importance as a source of information on the past, and a symbol of identity and pride, and for their socio-economic values. To face these challenges, the preparation is hopelessly inadequate often due to a series of misperceptions (Canuti et al., 2000; UNESCO, 2000). It is ironic and depressing to witness that the vulnerability of heritage properties to disasters is usually recognized after the damage is caused by a catastrophic event. Earthquakes in Bam (Iran), Prambanan Temple Compounds (Indonesia), Calabria, L'Aquila and Emilia (Italy), fire incidents in Edinburgh (UK), destruction due to armed conflict in Bamiyan (Afghanistan) are just a few examples of natural and manmade perils actually causing irreparable damage. It is important to underline that well managed and restored cultural heritage positively contributes to reduction of disaster risk (UNESCO, 2000). However UNESCO's recent efforts are a ray of hope towards ensuring sustainable risk reduction in the face of disasters. Their 2009 "Training Course on Disaster Risk Management of Cultural Heritage" proved to be the first stepping stone, launching a healthy debate in this regard (UNESCO, 2009). The course called for the need for action in the wake of many World Heritage properties lacking any established policy, plan or process for managing (controlling and reducing) risks associated with potential disasters.

The recent developments by UNESCO definitely seem to be contributing towards the risk preparedness in the face of disasters. However cultural heritage buildings, owing to their age, location and previous maintenance – and facing vulnerability from a number of risks and hazards, rare and catastrophic, and continual and slowly damaging, originating from diverse material composition and geographical spread of heritage structures – need constant up-keeping. The threat is so serious that if preventive and mitigating measures are not taken, the properties may deteriorate, decay and destruct. Responding to these threats, restoration is carried out, which is the methodological moment when the building is appreciated in its original material/structural form, and in its historical, social and aesthetic triality with a goal to pass it on to the future generations (Brandi, 1977).

Due to increasingly severe degree of risk to the cultural heritage, the restoration activities on these buildings seem to picking up the pace. However debated their importance, these cultural artifacts offer benefits in contexts of architectural ingenuity, economic sustenance, social and political identity, and spiritual values. Restoration projects aim at providing the correct maintenance of cultural heritage in order to enrich the future (Lichfield, 1998; Garrod et al., 1996; Lee, 1996; Feilden, 1994). However these are extremely tricky and sensitive undertakings; an overwhelming amount of stake is ventured which may have some serious consequences. For, although appropriate, it is not enough to decide for a heritage site to undergo restoration and maintenance in order to respond to disastrous hazards only. Had the restoration of historical architecture been such an easy task, less failure stories would have been reported (The Guardian, 2013; Fulmer, 2012).

However, when a restoration activity fails, it is far different than failure of any other capital venture where most of the stake can be converted into monetary units, and extent of overall damage studied and analyzed. In case of restoration undertakings, the failure may cost way more than what meets the eye; the intricate combination of use and non-use values, based on the non-market and contingent valuation techniques, no matter how complex to calculate, will eventually show a sum far greater than invested for the restoration works (Navrud and Ready, 2002). This provides the point of departure towards critically understanding what may go wrong in a restoration project and how it may be managed and controlled. The increasingly important question "*Why should engineers be interested in bizarre systems?*" (Kercel, 2000) seems so perfectly positioned here; the need to have an anticipatory system cannot be overstated in this case.

In other words, there is a research impetus for integration of standard project management (PM) and project risk management (PRM) theories and practices into the restoration of immovable cultural heritage projects.

Based on the gathered information (literature review, online surveys and personal interviews), it is evident that the penetration of formal practices of PM and PRM in the realm of restoration is yet to be realized. However, at this juncture, the more important question is about the extent of possible value-addition that may be achieved by this incorporation. Borrowing the motivation from other industries (Lappe and Spang, 2013) and more specifically the construction industry (Love and Irani, 2003; Edum-Fotwe and McCaffer, 2000), it can be reasoned with sufficient degree of certainty that systematic implementation of PM has warranted substantial accomplishments in terms of project goals. Taking on the inspiration, it is conceived that the integration of formal PM and PRM methods will not only ensure a more systematic approach towards restoration projects (and ensuring higher success rate as a result), but the motivation for the diffusion is all the more pertinent with mounting emphasis on sustainability.

Cultural heritage has been gaining momentum at the global, national, and local levels due to major significance towards sustainable development and its components of environmental protection, and socioeconomic development (Kobe Report, 2005). The increasing emphasis over sustainable development is more relevant in the context of cultural heritage as it is one of the few areas which have an effect upon all three pillars of sustainability: economy is associated with the commercial nature of these artifacts; society is at the core of cultural heritage as it represents historic and social affiliations; and environment (in terms of environmental changes and challenges) has a direct impact on these artifacts due to their old age and inherent fragility.

Thus the involvement of sustainability indicators/drivers seems relevant. The substance is established; however its degree needs more emphasis.

Social implications of cultural heritage restoration are influenced owing to the disappearing world heritage in the developing and underdeveloped world, which is a major social challenge as it represents a common historic legacy of particular country/region. Restoration projects aspire to pass the heritage on to the coming generations who can appreciate the ancient marvels of their forefathers.

Environmental implications of restoration projects are considerable as well; the previous use of unhealthy materials and products, the amount of construction waste, etc. are sustainability concerns which need efficient management. If the modern restoration takes into account these concerns, it will not only favorably affect the environmental degradation, but will also positively contribute towards environmental development and enrichment.

Economic implications of cultural heritage restoration are linked to the commercial nature of these structures. Most of the cultural heritage buildings are capable of raising revenues; therefore it is important to perform cost-benefit analysis along with other financial and economic investigations before making any restoration decisions. The sustainability further implores to respect the monetary factors as the heritage is considered as a common human endeavor.

It is opportune to realize and appreciate the exceeding complexity of restoration decisions: the impact of an erroneous choice may cost dearly to the building, society and economy, thus posing a threat to the sustainability. Hence, in retrospect, the resolve to restore is a tricky undertaking in itself which needs some serious risk management and impact assessment.

Another important complexity-emergent phenomenon is the relationship between various stakeholders and actors in the context of cultural heritage. A regular project, with 2 (or 3) stakeholders represents a certain amount of complexity of relationship. Imagine the kind of exponential increase in this complexity when a historical building is under consideration, where the ownership – although state/region authorized – is not so clearly established. To add into the drama, the roles of various other local and transnational groups, institutions, authorities, funding agencies and interest groups increase the complexity of decision-making manifolds. Streamlined project management may greatly help in not only ensuring a seamless project execution but also ensuring future fluidity of relations.

As an attempt to counter these challenges, this research aims at introducing the concepts of PRM in restoration projects, proposing a practical framework consisting of PM process and parallel PRM actions, and taking it one step ahead by motivating the industry to actually implement it. The framework provides a specialized process for managing risks in restoration projects. As an evidentiary move, a couple of case studies are run over the proposed framework, employing the suggested techniques and lifecycle process. The results, in the form of feedback from project managers of these restoration activities are highly motivating, providing an inspiration to continue and improve this line of research.

Part-1

State of the Art

CHAPTER 1
CULTURAL HERITAGE

Cultural heritage is broadly defined as consisting of movable and immovable, tangible and intangible heritage with strong historic, artistic, scientific, social, economic and cultural values of identity (Kobe Report, 2005; UNESCO, 2005; Harvey, 1997). Goods of cultural heritage include monuments, buildings, historic ensembles, works of art, crafts, documents, literary works, ethnological treasures, archeological remains, and even the intangible attributes such as oral traditions, unwritten languages and folklore (Bedate et al., 2004), which are of “exceptional universal value from the point of view of history, art or science” (Veco, 2010).

1.1: IMPORTANCE AND VALUE

Cultural heritage corresponds symbolically to the systematic organization of a country and is vivid symbol for its culture and tradition (Lee, 1996). For this work, the focus is on the largest subset of cultural heritage components; buildings, monuments and structures. Cultural heritage has been gaining momentum at the global, national, and local levels due to major significance towards sustainable development and its components of environmental protection, and socioeconomic development (Kobe Report, 2005). It is important for the pride of host nation and community, and their internal cohesion (Bedate et al., 2004; UNESCO, 2000).

Although the value and authenticity of cultural heritage cannot be assessed by fixed criteria (Bedate et al., 2004; ICOMOS, 2003), attempts are still made to comprehend its cultural significance (Mason, 2002; Sanz, 2003; Sanz et al., 2003; Bowitz and Ibenholt, 2009). The reason behind this exertive pursuit is that values, be them the historic or cultural (UNESCO, 2000), strongly shape the conservation decisions (De la Torre and Mason, 2002; Plaza, 2010).

A detailed work by Mason (2002) has unearthed and assembled together an abundance of value components such as sociocultural (historical, cultural/symbolic, social, spiritual/religious and aesthetic) (Bedate et al., 2004) and economic (use, nonuse (Herrero, 2001; Hutter and Rizzo, 1997; Rizzo and Towse, 2002)) values (Bandarin et al., 2011) which describe the importance of cultural heritage. Cultural heritage is vulnerable to a number of risks and hazards, rare and catastrophic, and continual and slowly damaging, originating from diverse material composition and geographical spread of heritage structures (Brokerhof et al., 2007). Despite the prominence and significance associated to cultural heritage, the literature review does not yield a sizeable number of risk taxonomies, normally found in other engineering fields. In any case, the published taxonomies (Michalski, 1990; Michalski, 1994; UNESCO, 2000) (which are although being partially targeted to specific cases) can be generalized and utilized for cultural heritage.

1.2: RISKS AND HAZARDS TO CULTURAL HERITAGE

Apart from others, cultural heritage is threatened by following major categories of risk (UNESCO, 2000), namely: meteorological, hydrological, geological or geomorphologic, biological, astrophysical, human-induced, and climate change. It is evident that a lot of focus has been driven towards physical aspects, leaving behind the derivative characteristics of economy, sociology, society and culture.

In any case, the cultural heritage is at the forefront of risks which are less natural in their dynamics, if not in their cause. The list goes on from floods, mudslides, landslides, coastal erosion, fire, earthquakes and manmade hazards such as civil unrest, industrialization, chemical waste etc. To face these challenges, the preparation is hopelessly inadequate often due to a series of misperceptions (UNESCO, 2000; Canuti et al., 2000).

The vulnerability of heritage properties to disasters is usually recognized after the damage is caused by a catastrophic event. Earthquakes in Bam (Iran), Prambanan Temple Compounds (Indonesia), Calabria, L'Aquila and Emilia (Italy), fire incidents in Edinburgh (UK), destruction due to armed conflict in Bamiyan (Afghanistan) are just a few examples of natural and manmade perils actually causing irreparable damage. It is important to underline that well managed and restored cultural heritage positively contributes to reduction of disaster risk (UNESCO, 2000).

An extremely pertinent dimension to cultural heritage restoration risk deals with the stakeholder participation and interaction. In a typical project, three prime stakeholders interact with each other, as shown in Figure 1-1, and sway the decision-making; in particular, the owner claims the lion’s share. It is important to define project owner: project owner is an individual, a group, a public sector department or an organization; in short an entity, who initiates a project (PMI, 2008a), bears the financial burden of its activities in principal or in partnership with other financial and capitalist groups (including banks, DFIs, venture capitalist funds, hedge funds, etc.), contracts it out to a suitable service provider, and benefits from its output(s) (Turner, 2009).

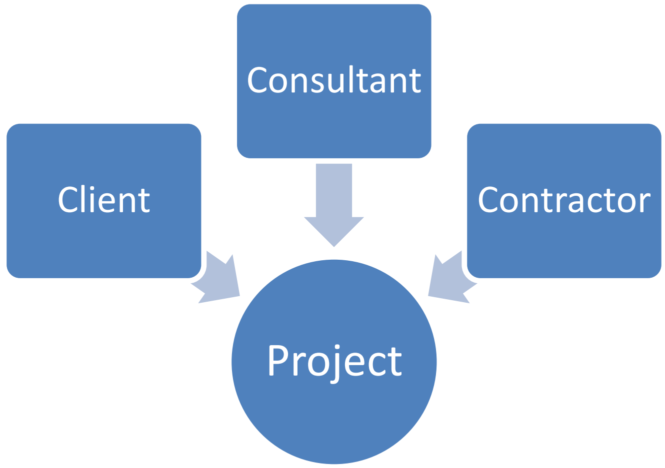

Figure 1-1: Prime stakeholders in a typical project

Other than owner, consultant/engineer and contractor are important stakeholders. The client-contractor relationship is ever strained and in the construction industry particularly the prevalent procurement methods and contractual arrangements have historically driven the clients and contractors to find themselves at the opposite sides of the bet as adversaries, aggravating and reinforcing any differences in values, goals and orientations that may exist within the project team (Banwell, 1964; Higgin and Jessop, 1965; Morris, 1973; Cherns and Bryant, 1984; Ball, 1988; Latham, 1994).

However, the recent scholarship in this area warrants for increasing demand for partnership, collaboration and cooperation not only between the client and contractor (Drexler Jr and Larson, 2000; Bresnen and Marshall, 2000) but also between client and consultant (Turner and Müller, 2004). This aims at ensuring project success by not only respecting the traditional triple constraints but also incorporating additional intangible aspects (Shenhar and Dvir, 2007).

Any project, other than the myriad of indirect constraints from project management point of view (stakeholder anticipations, social and cultural restrictions, environmental regulations, statutory parameters, sustainability indices, etc.), is constrained by three fundamental drivers: time, cost and quality/scope. Triple constraint is a model of the limitations on a project. It is a graphic representation of project attributes which are plotted on the edges of a triangle to show opposition as shown in Figure 1-2. There is an elastic relationship between the three constraints; increase or decrease in any driver will directly affect the others. This graphical system is instrumental for intentionally choosing project partialities, or analyzing the goals of a project. Though it may seem little too naïve to state, the project management success may be measured by the project team's ability to manage and complete the project in rough manner, so that the specifications are implemented onsite while sticking to time and cost restrictions (Van Der Westhuizen and Fitzgerald, 2005).

Figure 1-2: Triple constraints of a construction project

The triple constraint model aims at Zero-Sum-Gain perspective; considering a fixed aggregate performance; it appreciates the high elasticity of relationship and tradeoff between better performance in more critical dimensions at the cost of poor performance in less important ones.

Returning back to the cultural heritage restoration context, the nature of stakeholders and their relationship is not necessarily tantamount to that of construction industry. The ownership of these artifacts has had its fair share of confusion, legal battles and even physical conflict (Blake, 2000; Harding, 1999). Steering safe of the legal and statutory debate, it is however imperative to point towards the fact that a restoration project involves a multitude of prime stakeholders, which although have a common interest at higher level, can be characterized by differing nature of their short-term goals. The variety of stakeholders not only creates this *soft* risk of coordination and communication but also aggravates the conditions which my directly threat the success of restoration project.

Following is a detailed list of various public and private stakeholders;

- Public Stakeholders
    - Relevant government departments
    - Federal and provincial/regional government authorities dealing with cultural heritage
    - Departments of finance, commerce, natural and historical resources
    - Research and Development centers and universities
    - Academic institutions

    - Public at large
- Private Stakeholders
    - Renovation and rehabilitation companies
    - Private contractors and suppliers
    - Property/land owners nearby sites of cultural heritage

Apart from these stakeholders, international stakeholders like UNESCO (World Heritage Program), ICOMOS (International Council on Monuments and Sites), ICPICH (International Commission for the Prevention of Islamic Cultural Heritage), etc. also play a very important role in the evolution of these projects.

Any typical cultural heritage site experiences the interaction of almost all the specified public and private stakeholders, and sometimes also of the international stakeholder(s). With the concern to prevent, rehabilitate and recuperate the cultural sites, these stakeholders play their active roles and there comes a point where one of them points towards a situation where the constant action of other stakeholder (usually public at large) has been deteriorating and jeopardizing their efforts. At this stage, technology as it is introduced as yet another stakeholder, providing an evolution of restoration projects.

It must be noted here that improved restoration and rehabilitation techniques, better chemical, natural and synthetic materials and above all a highly productive management of restoration of cultural heritage is the reason of this constant interplay and relationship of these stakeholders and if today we see some of the heritage preserved, it is due to the successful interaction between stakeholders. Unfortunately, cultural sites which have been wiped off the surface of earth are mainly due to weak or no interplay between stakeholders and consequent lack of interest among some of them which has caused complete devastation and desolation of some of already endangered cultural heritage. It was the main motive behind creating of UNESCO World Heritage Program!

Mapping the stakeholders in restoration sector graphically brings out a complex structure, as shown in Figure 1-3, which only hints towards the possible complexity in such projects from one specific perspective. Undoubtedly, such complexity is at the core of some of the most disastrous risks.

Figure 1-3: Possible stakeholders in cultural heritage restoration projects

1.3: RESTORATION AND WHY RESTORE

Restoration is the methodological moment when the heritage building/structure is appreciated in its material/structural form and in its historical, social and aesthetic triality with a goal to pass it on to the future generations (Brandi, 1977). The general philosophy behind restoration has been to *"ensure stability and durability with the interventions as delicate as possible with respect to the original conception and the history of the monuments"* (Croci, 2000). Restoration of cultural heritage, owing to its positive (or otherwise) consequences on the architectural, economic, social, political and spiritual values (Feilden, 1994; Lee, 1996; Lichfield, 1988; Garrod et al. 1996) is increasingly warranted in contemporary times.

One of the motivations of undertaking such complex projects comes from a varied sense of project success. When a construction (or any other capital) project fails, the implications, which may be disastrous in their nature, are distinct and obvious. The loss of resources cannot be justified; however the seemingly unsurmountable damage is not necessarily indispensable; it can be recuperated with effort. On the other hand, failure of a restoration project may mean jeopardizing the integrity of cultural heritage artifact; by implication, it may be tantamount to loss of the very monument which was attempted to be saved in the first place.

The goal of intervention, which requires a multidisciplinary approach, to an historic structure that must be considered within the context of restoring the whole building (ICOMOS, 2003), is to provide the correct maintenance of cultural heritage in order to improve and develop the future (Pinheiro and Macedo, 2009).

Nevertheless, prioritizing the interventions due to economical limitations turns out to be a difficult task. In order to respond to this criticality, it is imperative to establish a generic and systematic approach, taking onboard various stakeholders and driving forces, for fixing priorities (Pinheiro and Macedo, 2009; Perng et al., 2007; Kim et al., 2010). Researchers have come up with some very sophisticated methods of selecting a suitable candidate for intervention among many (Gizzi, 2008).

It may conclusively be established from the proceeding discussion that the risks posed by restoration projects are serious in nature and need to be managed scientifically. Therefore the processes of project management (PM) and project risk management (PRM) must be vital and momentous concern as, if not managed, risk may cause failures (Royer, 2000; Krane et al., 2010). PRM is defined by PMI (PMI, 2009) as a subset of project management with four component processes: risk identification, risk quantification, risk response development and risk response control (Ward, 1999).

Conclusively, it can be deduced that the application of formal PRM in the field of restoration of cultural heritage buildings is imperative. Derived from the lack of relevant literature and industry practices, it is advisable to explore the applicability of PRM in restoration projects.

Restoration of cultural heritage buildings, in the face of ever-uncertain and risky future, has become a booming trend world-wide due to the emphasis on its benefits concerning architectural, economic, social, political and spiritual values (Feilden, 1994; Lee, 1996; Lichfield, 1988; Garrod et al. 1996). Its goal is to maintain the originality and to provide the correct maintenance of cultural heritage in order to enrich the future (Pinheiro and Macedo, 2009). The restoration, like any other project, is prone to risks. Apart from the maintenance of originality as the most important risk in restoration projects, some of the other important risks can be the availability of knowledge of material, construction techniques and specialized workforce (Croci, 2000; Grama et al., 2011; Wang et al., 2008). The intricate nature of the restoration projects and involved risks demand for a systematic and formal project management (PM) and project risk management (PRM) approaches respectively. Not only such a methodical attitude but also the very diffusion of risk management in the literature seems lacking. Additionally, the gap does not only seem to be limited to the literature, but it is deeply rooted in the culture of restoration projects.

Thus this work introduces the concept of PRM in restoration projects and takes it one step ahead by motivating the industry to actually implement a practical framework of PM and PRM presented in proceeding sections.

Disasters – of natural and artificial nature – are the core concerns for conservation experts. The literature is jam-packed with knowledge areas of 'disaster risk management' (Kobe Report, 2005; Peek and Mileti, 2002) and 'preservation risk management' (Waller and Michalski, 2004; Ashworth, 2001; Caple, 2000; Weller, 1994). These disasters pose ever-growing threat to the integrity and safety of heritage buildings. Though it is beyond the scope of this thesis to argue over the need to restore such buildings, it will be sufficient to mention that these buildings represent history, community and national values and above all a sense of identity (Wangkeo, 2003). International giants, such as ICCROM and ICOMOS, have done a lot of work on the risk preparedness and prevention strategies to cope up with these disasters and as a result, international conventions have been formulated. Also recommendations have been published for analysis, conservation and structural restoration of cultural heritage. However conclusive evidence suggests that sometimes these calamities get the better of human effort and end up with disastrous aftermath (Taboroff, 2000).

Restoration, preventive or corrective, is carried out in order to reinstate the historic building in as much its original shape as possible. The restoration activity is a custom-built undertaking for every heritage artifact based on their variety and nature. Generic guidelines are available but fitting with specific conditions, tailor-made actions are inevitable, giving raise to adhocism. As a result, there is always a tremendous amount of uncertainty involved in these projects. Therefore, restoration projects are largely affected by risks. Historic buildings are more vulnerable during building works than at any other time in their lifecycle. Apart from the maintenance of originality, some other most important risks are the lack of availability and knowledge of historical material, uncertainty of construction techniques employed, and the availability and capacity of specialized workforce (Grama et al, 2011; Wang et al, 2008; Croci, 2000).

Therefore, the intricate nature of restoration projects and the involved risks demand for a systematic and formal PM and PRM approaches respectively. It also demands to clearly and distinctively address the assessments of risk and impact: the former involving exposure to danger (or wellbeing), whereas the later referring to occurrence of risk. In his influential work, Bellance (2011) argues for and attempts to establish a methodical approach towards the restoration of historic architecture, yet the need and incentive for incorporating management approaches to restoration seem overlooked. The literature in general seems lacking of a methodical attitude, and the diffusion of risk management techniques and standardized practices compared to other fields and industries. Nevertheless, it is believed that there is enough rationale to advocate for this methodical attitude towards restoration by integrating the theories, practices, tools and techniques of PM and PRM. In addition, the gap does not appear to be limited to the literature only, but it seems deep rooted in the culture of restoration projects. Ideally, these processes must be vital and momentous concern as, if not managed, risk may cause project failures (Krane et al, 2010). Taking on the motivation, it can be deduced that there is the need to disseminate the knowledge of PM and PRM (and their affectivity) in restoration sector, and learn the lessons from construction industry as both share some common features. However, the former still demonstrates different dynamics and challenges, and demands for corresponding responses.

The construction industry is characterized by carrying out green field building activities using the prevailing materials and techniques, whereas the restoration industry deals with the existing entities made up of ancient and oftentimes outdated materials posing risks of their own kind (Pinheiro and Macedo, 2009; Cultural Heritage Bureau, 2005). The ages-old construction techniques which were employed for them are also not necessarily well documented and preserved. The as-built drawings and specifications are usually non-existent. In the midst of this uncertainty, the restoration projects are aimed at maintaining the originality and ensuring that the restoration 'therapy' will respect the subject (building/monument/structure) and its fragility. If managed scientifically, these risks along with their affect can be minimized, potential opportunities can be exploited and project objectives, in terms of schedule, budget, quality, scope, originality, safety, sustainability, etc. can be affectively achieved.

Looking at the available literature, industry practices and the gravity posed by the reported risks, it is imperative to have a formal and specialized PRM process for restoration projects. However, it is still not practically introduced and employed due to apparent lack of motivation towards PM in the restoration industry. Of the few available material, ICOMOS (ICOMOS, 2003) has somehow pioneered the concept of risk in restoration and rehabilitation projects. Another notable 'intergovernmental organization dedicated to the preservation of cultural heritage worldwide through training, information, research, cooperation and advocacy programs' (ICCROM, 2013) has also been striving to incorporate the risk management knowledge in cultural heritage (ICCROM, 2009).

1.4: PROJECT MANAGEMENT AND RISK MANAGEMENT IN CULTURAL HERITAGE

The penetration of formal management theories and practices in the field of cultural heritage is more focused on heritage management and tourism, whose importance for tourism development cannot be ignored though (Prentice et al., 1994), is more focused on exploitation (for economic, social and wellbeing purposes) of *'finished'* product. It is imperative to note here that careful upkeeping and management, on one hand, may enhance the site's life (Feilden and Jokilehto, 1993); however, the downside scenario implies a rapid degradation of cultural heritage due to overuse/overburden by spectators and visitors (Aas et al., 2005). As a result, when such monuments and buildings undergo restoration process, there seems a rampant scarcity of managerial input both in terms of project and risk areas. This neglect, which may be described, at best, as mis-appreciation of complexities of restoration activities, may cost dearly to the stakeholders. Thus it is warranted that some serious and aggressive work is done in this regard, employing multidisciplinary skills, integrating the knowledgebase in order to ascertain the success of restoration projects.

As discussed before, the usual connotation with which risk is treated is in terms of potential problems or negative outcomes. However, in the field of project management, a risky event may also have a positive outcome (opportunity), as illustrated in Figure 2-1 and Figure 2-2. According to ISO 31000 standard, risk is defined as "the effect of uncertainty on objectives, whether positive or negative".

1.5: NON STANDARDIZATION OF RISK MANAGEMENT PRACTICES IN RESTORATION PROJECTS

Standardization is the process of developing and implementing technical and managerial standards and guidelines. It helps in communicating through the set rules and procedures to ensure that the focus is maintained. The method is made to facilitate processes and tasks. Though the existence of a published standard does not necessarily imply that it is useful or correct, it nevertheless provides a consistent methodology of implementing strategies and realizing goals. Some of the sectors may advocate against the standardization of risk management (Deloitte, 2010), it is nevertheless opportune to mention that *Black Swans* events[1] are non-frequent in their nature, unlike risk in a project. Since risk management is advocated to be a routine job, black swans must not be allowed to jeopardize its practice and standardization.

[1] Black swans are such events which are exceptionally rare in their frequency but extreme in their impact and significance. They seem completely unimaginable before they occur but once materialized, they make perfect sense.

Another argument against standardization is its supposed tendency to curtail freedom of work (Polesie, 2009). Project managers perceive freedom as means to find value in their work; it bestows upon them the sense of importance and significance. Although individual freedom is usually characterized by uniqueness, which is suggested to hinder standardization (especially in construction industry), with freedom comes the responsibility (Polesie et al, 2009). The importance of freedom cannot be emphasized enough; however it is opportune to argue that it further amplifies the already exaggerated level of adhocism rampant in restoration projects.

Although PMI has published its Practice Standard for Project Risk Management (PMI, 2009), the level of implementation is still restricted owing to the fashion this standard has been developed. This must not be treated as a critique to the quality of PMI's standard; it is however taken from PMBOK without much of effort. The PMI (2008a) body of knowledge has achieved tremendous results when it comes to project management practices; it unfortunately falls short of risk management excellence. But no matter however mature (or otherwise), the implementation of project risk management in restoration projects is, at best, inadequate. This hinders the foresight ability of (head-on) confronting the mission critical situations. The emphasis, however, is satisfactory in the area of risk preparedness in the context of disasters and their implications to cultural heritage.

CHAPTER 2

PROJECT RISK MANAGEMENT, APPROACHES AND TOOLS

2.1: RISK AND RISK MANAGEMENT

We take risk into consideration in our daily life. A simple task such as crossing the street is not done without carefully looking and checking for incoming traffic from both sides. Likewise, every project manager or employee takes risk into consideration in their daily work. The term 'risk' is not born in the field of engineering or management; these fields only exploit the application of risk. The term goes deep down into human cognition: it has multiple dimensions; behavior, neurology, psychology, sociology, etc. However, the pioneering application of risk was in the field of economics.

The continuum of risk encompasses both the directions: the outcomes may not align with originally expected and planned ones. These are known as opportunities (upside risk) and threats (downside risks), as shown in Figure 2-1. In a project, anything ranging from estimated budget at completion to scheduled duration of any subcomponent, subcontract, operation or activity may be exposed to risk and uncertainty. Thus, risk and uncertainty will be attached to assumptions and probabilities about weather, inflation, strikes and other external aspects of projects.

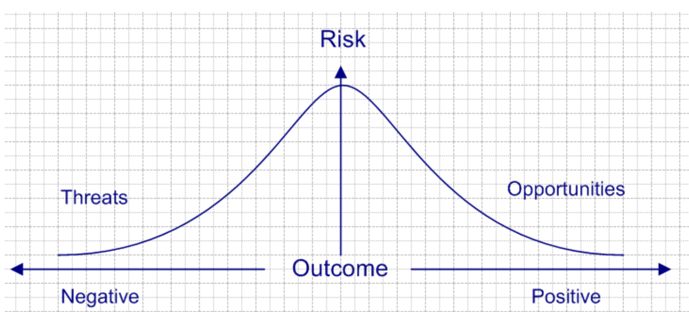

Figure 2-1: Risk and its outcomes

Taking these later points into account, risk may also be defined as *"exposure to the possibility of economic and financial loss or gain, physical damage or injury, or delay as a consequence of the uncertainty associated with pursuing a particular course of action"* (Chapman and Cooper, 1983).

British Standard Code BS 4778 defines risk as a growing *"combination of likelihood (probability) for a certain problem to occur with the corresponding value (impact) of the damage caused"*. On any project, a problem is an unwanted situation which may potentially (or create situation leading to) jeopardize the project objectives. Risk is the occurrence of a negative event or the non-occurrence of a positive event

(PMI, 2008a). *"When there is a risk, there must be something that is unknown or has an unknown outcome. Therefore, knowledge about risk is knowledge about lack of knowledge. This combination of knowledge and lack thereof contributes to making issues of risk complicated from an epistemological point of view"* – Stanford Encyclopedia of Philosophy.

"Risk and uncertainty characterize situations where the actual outcome for a particular event or activity is likely to deviate from the estimate or forecast value". [Risk Analysis in Project Management (Raftery, 2003)].

In order to manage this increasingly complex notion of risk, the concept of risk management was introduced and later made part and parcel of Project Management areas of knowledge by PMI. Risk management requires a high level of project management skills and knowledge; it is a challenging area for project managers worldwide. Although almost everyone agrees to have a 'good risk management program', it is nevertheless little tricky to define one owing to the intricacies of common nomenclature and lack of managerial knowledge among practitioners. PMI (2008a) defines risk management as *"the systematic process of identifying, analyzing and responding to project risk. It includes maximizing the probability and consequences of positive events and minimizing the probability and consequences of adverse events to project objectives"*.

Appropriate project management training and courses cover the essential skills which reinforce project managers for achieving project objectives, whilst managing any risks. One of the key current dilemmas faced by risk management is the gap between common practices and best practices. Opinions are divided on the scale and nature of this dilemma. However, it is assumed that this thesis will prove to be instrumental both as a reading and policizing for experts and novices all along. Best attempts are made to address the need for simplicity without being too simplistic in a direct manner.

In contemporary times, project success is swayed by risk and its management in any capital project (Krane et al, 2010). Risk management ought to be a fundamental matter for project managers as poorly managed or mitigated risks are at the center of project success or failure (Royer, 2000). Similarly, the complex nature of stakeholder relationships additionally emphasizes for the need for efficient risk management (Artto et al, 2008).

The prerogative of the management to decide for setting the expected or target value can be argued, which, in result, determines the range of variation to be considered "normal" for any given type of project, but the fluctuation outside this range on both sides is always possible – and often unacceptable.

As a result, there may exist opportunities to do better than plans and threats do worse, as illustrated in Figure 2-2 (Hillson, 2004).

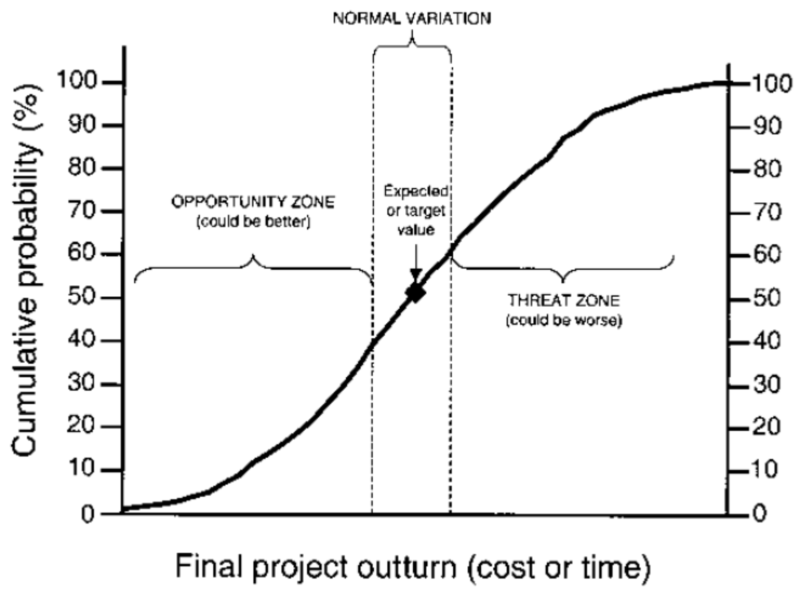

Figure 2-2: Threat and Opportunity in project outturns, Source: (Hillson, 2004)

2.2: RISK CLASSIFICATION

The literature and international associations propose different ways to classify the risk. The most common are the ones based on the nature of the risk and according to the risk definition itself, without importance of the classification. The sources of uncertainty in a project can be associated to six elements, as illustrated in Table 2-1 and Figure 2-3, which are interrelated and cover all the project aspects (Chapman and Ward, 2007).

Ws		
Who	Who are the parties involved?	(Parties)
Why	What do the parties want to achieve?	(Motives)
What	What is it the parties are interested in?	(design)
Which	How is it to be done?	(Activities)
Wherewithal	What resources are required?	(resources)
When	When does it have to be done?	(timetable)

Table 2-1: The Six Ws

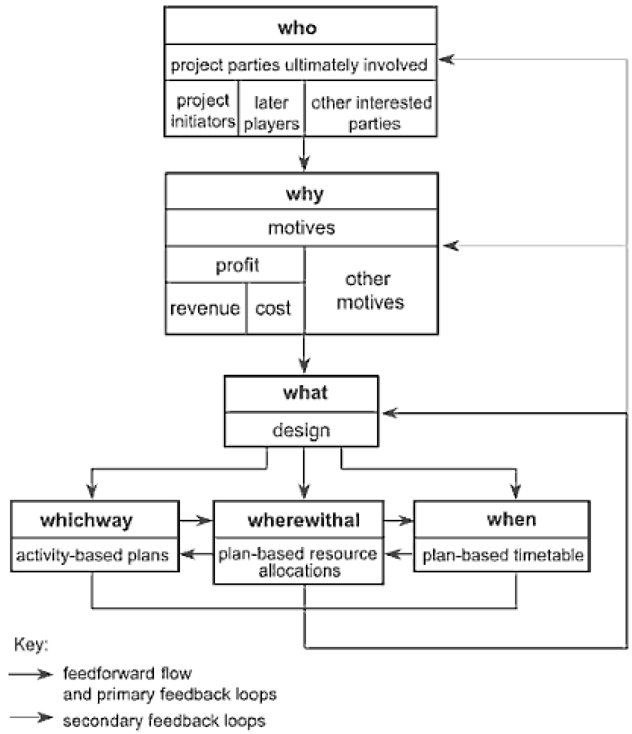

Figure 2-3: Project definition process, **Source: Chapman and Ward, 2007**

The risk can be classified into two major categories: internal risk; within the control of the project manager and external risk; outside the control of the project manager (Futrell, 2002). Furthering this categorization, internal risk could be divided into technical and nontechnical risks (Turner, 2009):

- Internal technical risks: they are influenced by the technology of the project, or the design, construction, or operation of the facility, or the design of the ultimate product. A failure to attain the project level of performance contributes towards internal technical risks.
- Internal nontechnical risks: a failure of the project organization or resources (human, material, or financial) to attain their anticipated functioning cause such risks. The apparent consequences may materialize in the shape of schedule delays, cost overruns, or cash flow commotions.

External risk can be divided into predictable but uncertain and unpredictable risks (Turner, 2009):

- External predictable but uncertain risks: the ones with reasonably predictable outcome. Their occurrence is similar to the outcome of tossing a coin. There are two main categories of this risk: the first pertains to market activity for raw material or finished goods influencing price, availability, and demand; the second category deals with the effect of fiscal policies on currency, inflation, and taxation. Operational requirements (such as maintenance), environmental factors (such as the weather), and social impacts also fall in the purview of this type of risk.

- External unpredictable risks: they are more ambiguous, with possibly unknown potential outcomes. These risks are of *'force majeure'* nature, originated and influenced by external drivers, such as governmental actions, acts of God, or failure due to external influences. Government can unexpectedly pass a new regulatory requirement. Third parties may also aid into the uncertainties, aggravating the problems in a number of ways, such as sabotage or war. The acts of God or natural hazards – force majeure – refer to catastrophic physical conditions, such as earthquake, flood, tornado, tsunami, volcano eruption, etc. Third parties may further aid into failing a project completion through bankruptcy or design failure. Owing to their force majeure characteristic, almost all these risks are insurable, which is considered to be a smart strategy.

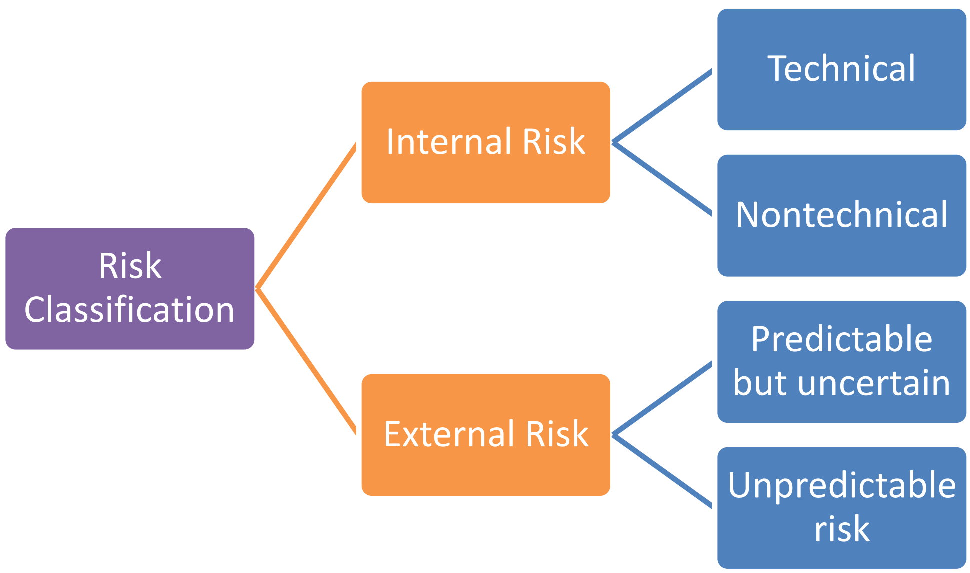

Figure 2-4: Risk classification

Figure 2-4 illustrates the risk classification which can also be categorized based on insurability. In the insurance industry, the risks for which insurance is provided are restricted to financial losses (Swart, 2004). This financial risk is subdivided into:

- Pure risk: the risks with no possibility of profit or benefit, only of loss. A home destroyed by a fire is an example of the pure risk, since the owner of the house would not normally derive any financial benefit from such an event.
- Speculative risks: the risks where either a profit or a loss may occur. Investment in shares is an example of speculative risk.

The last classification is based on the degree of certainty and clarity of project details. This categorization divides the risk into four types of uncertainty (variation, foreseen uncertainty, unforeseen uncertainty and chaos) (De Meyer et al, 2002). This degree of uncertainty could be combined in a project. In order to understand this classification, the categories are described below:

- Variation: seemingly minor and small alterations and influences cause variation which, in turn, causes time and budget fluctuations in a predictable range. These events could be: illness of labor force, weather, delays in logistics of material and machinery, unexpected site problems, etc. From the outset, these apparently minor effects seem too trivial to plan for and monitor individually; however, the project team may consider the effect (in terms of time and money) and notice the diversions. A solution for this uncertainty is planning buffers in strategic points of the project and allowing for some controlled flexibility in the budget.
- Foreseen uncertainty: it is an array of recognizable and known influences; however, their occurrence is uncertain. In simple words, these are the project risks which are identified but their occurrence is probable. In order to counter and contain them, contingency plans are formulated which, though may never be used, provide a cushion if any side-effect occurs in the project.
- Unforeseen uncertainty: this type of risk cannot be identified during the project planning which means that, for such a risk, it is not possible to have a plan B. Such risks are emergent in their nature which may arise from unexpected and complex interaction of many individually foreseeable and predictable events/actors. It is particularly present in projects that push a technology envelope or enter a new or partially known market. Further, the interactional analysis between the (direct and indirect) stakeholders of international projects also gives rise to risks falling in this category.
- Chaos: in this case, everything is uncertain and unforeseeable, even the basic structure of the project plan may be chaotic and is definitely uncertain. This happens when there does not exist established technology; there may be constant innovation in progress or when the research is the main goal, which may aim at some end product but the means are completely uncertain. Therefore such projects yield results which may be termed accidental and unintentional; notwithstanding useful and valuable inputs with respect to project effort and investment.

This classification is especially important for understanding the balance between planning and learning. Planning offers organization, a set of well-defined activities to be followed and possible sudden inconsistencies which may materialize and need to be studied and monitored. However, the learning allows adapting to unforeseen events.

2.3: APPROACHES TO THE PROJECT RISK MANAGEMENT

The risk management literature is practically littered with several approaches and methodologies for the process of project risk management; some of them will be proposed in this investigation, all of them with a shared vision. Also, it is important to clarify that project risk management is a particular application of the risk management. There are two professional organizations that influence and dictate the development in the body of knowledge, set standards as well as issue procedural details: the Project Management Institute (PMI) based in US and the Association for Project Management (APM) based in UK.

Four widely used approaches to project risk management are the following, with each having lots of differences in their objectives, styles and terminology (Cooper, 2005):

- The PMI's Practice Standard for Project Risk Management and Project Management Body of Knowledge (PMBOK)
- The APM's Project Risk Analysis and Management (PRAM) Guide
- The Australian and New Zealand Standard AS/NZS 4360
- The UK Office of Government Commerce (OCG) Management of Risk (M_o_R) guideline

2.3.1: Approach by PMI

As already mentioned, PMI (2008a) describes project risk management as a *"processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project. The objectives of project risk management are to increase the probability and impact of positive events and decrease the probability and impact of events adverse to project objectives"*. The approach is graphically represented in Figure 2-5.

Figure 2-5: Risk management process according to PMI

These activities, implicated in the project risk management process, have their specific roles:

- Risk Management Planning: it is a policy level process where an organization decides how to approach the risks, plans and executes the risk management activities.
- Risk Identification: this process aims at establishing which risks might influence the project and detailing their attributes.
- Qualitative Risk Analysis: this process aims at analyzing the identified risks by evaluating and combining their likelihood of occurrence and impact in qualitative terms.
- Quantitative Risk Analysis: this process aims at numerically assessing the effect of identified risks in quantitative terms and their influence on overall project objectives.
- Risk Response Planning: this process aims at planning and elaborating opportunities and actions to stimulate prospects for exploiting, reducing and/or controlling the impact of risks.
- Risk Monitoring and Control: this process aims at pursuing the project risks, monitoring residual risks, identifying new ones during the project execution, implementing already agreed upon and finalized risk response plans while simultaneously gauging their effectiveness throughout the project lifecycle.

It is imperative to state that risk management is a cyclic process which helps in updating the activities and risk reports throughout the project duration. In this way, it is the fundamental objective of this process to escalate the probability and impact of progressive events and diminish the probability and impact of unfavorable factors to the project. Also once a risk is avoided (or mitigated), chances are new risk items (which may or may not be a direct effect of remedial measures) may emerge. Thus it is vital that new risks are identified and responded to during the project execution.

2.3.2: Approach by APM's Project Risk Analysis and Management (PRAM) Guide

The PRAM Guide is a stand-alone project management guide issued by Association for Project Management (APM). The focus of this guide is on the concerns which drive the project manager and it tackles the connection of the risk management process at project and corporate or program levels. The guide offers the up-to-date practices, opportunities, benefits and instructs regarding the behavioral issues. PRAM is a process, preemptive in its nature, aiming at either total removal or at least substantial reduction of project risks which jeopardize accomplishing the project objectives (APM, 2010). It separates the risk management process from detailed techniques or methods that might be used in different stages of the process (Bartlett, 2004). PRAM has historically been associated with mega projects with huge capital investments in specific industries such as defense, oil and gas, aerospace, and civil engineering. It may be deduced that the experience gained in the industries since more than 4 decades must now begin to circulate and penetrate into other industries such as ICT and manufacturing (APM, 2000). The detailed PRAM approach is illustrated in Figure 2-6. Its activities, involved in the project management process, have the following implications:

- Define Project: consolidate an unambiguous comprehension of all the pertinent features of the project.
- Focus PRAM: define the scope and plan various sub-phases and operations of PRAM.
- Identification: identify all possible risks and possible response options (preventive or mitigating).
- Assessment: implications of assumptions taken, risk ownership, importance of catching the risk, implications of responses.
- Planning: detail-based plan, prioritized risk assessments, recommended proactive and reactive contingency plans.
- Management: initiation of re-planning if required and exception reporting.

PRAM is a cyclic method which can be initiated at virtually any stage in the project lifecycle and can be continued until the cost-benefit tradeoff is favorable. With project evolution, the effectiveness gained by the use of PRAM may tend to diminish; therefore the optimum time to employ it is in the earlier stages of the project when management control is maximum.

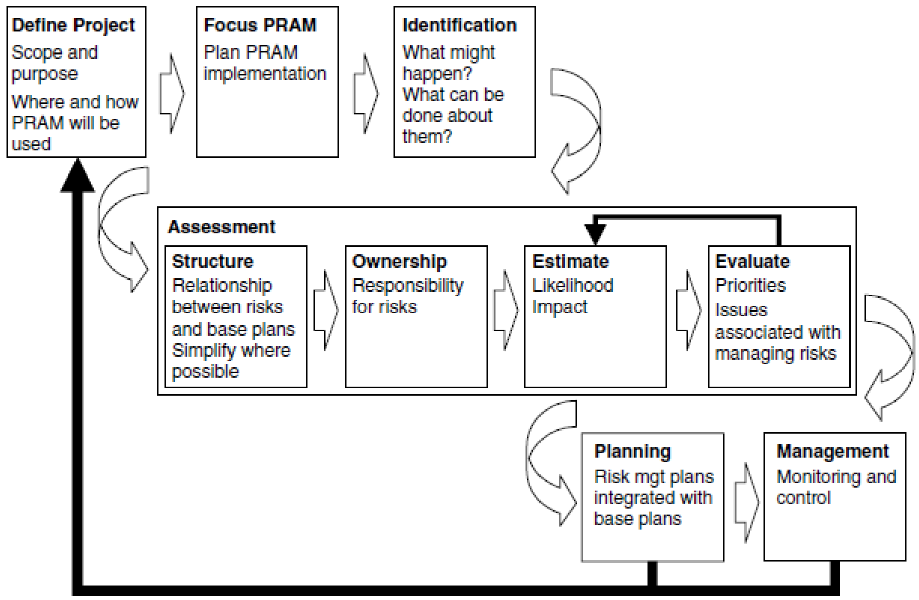

Figure 2-6: Risk management process according to PRAM guide, Source: Cooper, 2005

2.3.3: Approach by Australian and New Zealand standard AS/NZS 4360

The Australian and New Zealand Standard AS/NZS 4360 was first published in 1995, and updated in 1999 and later in 2004. It offers a broad framework which aims at setting the context, classifying, analyzing, assessing, handling, supervising and communicating the risk. According to official version, the most recent and modified standard integrates the insights gained and lessons learnt through the application of the previous editions, and emergent discussion on risk management in the field (AS/NZS, 2004). It is a generic risk management standard. It is not confined to projects only; on the other hand it deals with a variety of issues such as safety, financial and security risk management.

The standard describes an overall approach to risk management, not just risk analysis or risk assessment. The main features of the process, as illustrated in Figure 2-7, are the following:

- Communicate and consult: this is an organization level process which aims at collaborating, interacting and consulting with all the (internal and external) stakeholders throughout the entire cycle of the risk management process and concerning the process as a whole.
- Establish the context: this is a policy level process which focuses on setting the external, internal and risking management context, which will behave like an umbrella for rest of the process. This process further ascertains establishing risk evaluation criteria along with the organization of the analysis.

- Identify risks: this process aims at detecting where, when, why and how events affect the project success by preventing, damaging, delaying or even enhancing the significant drivers.
- Analyze risks: this process deals with identifying and evaluating the existing controls. It requires establishing the aftermaths and chances, hence the significance, of risk. The analysis needs to reflect upon the breadth of potential implications and their possible causes.
- Evaluate risks: this process deals with evaluating the assessed levels of risk against the pre-determined criteria (if any) which will result in understanding of tradeoff between prospective gains and losses. This process is a potential decision-making enabler aiming at determining the degree and nature of actions required and general priorities.
- Treat risks: this is a responsive process which deals with developing and implementing specific economical as well as profitable strategies and tactics for enhancing the potential benefits and controlling possible costs.
- Monitor and review: this is a supervising process which deems it necessary to supervise and administer the efficiency and success of the risk management process. This is vital to the cause of continuous improvement. It is important to monitor the risks and the effectiveness of response actions in order to observe the influence of changing circumstances on the project priorities and objectives.

As part of bringing to closure, AS/NZS 4360 advocates to record the risk management process. It is suggested that each stage of the risk management process should be documented for future references. This includes recording the project assumptions, methods, data sources, assessments, results and justifications for decisions. These documents form the core of important aspects of sustainable corporate governance as they help in building an organizational behavior and may be needed in future.

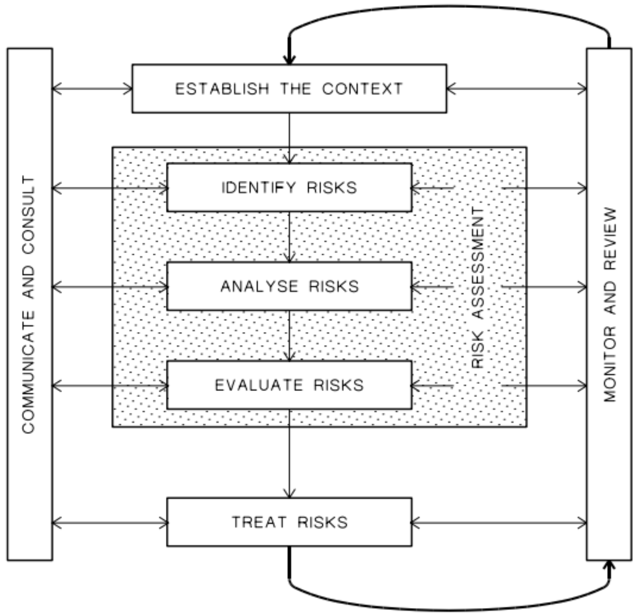

Figure 2-7: Risk management process according to AS/NZS 4360, Source: AS/NZS, 2004

In an attempt to globalize their outreach, agencies responsible for AS/NZS 4360 mandated the integration into and utilization of ISO 31000 in 2009. Thus, the ISO 31000:2009 is aimed at replacing the current AS/NZS 4360:2004, and imaginatively named as AS/NZS ISO 31000:2009. The scope of now defunct Standards Australia approach was focused on risk management as a process, with operative details, whereas ISO 31000:2009, targeting an all-inclusive approach, concentrates on the whole management system which are the core of design, implementation, maintenance and improvement of risk management processes.

2.3.4: Approach by Management of Risk (M_o_R) guideline

The Management of Risk guideline, known as M_o_R, is written for public sector organizations. It deals with all risks to an organization's success and includes guidance on the risk management process. The basic intention behind M_o_R guide is to facilitate the organizations for setting up an effective framework which is at the center of informed decisions regarding the risks which affect their performance objectives throughout their activities. It defines risk as *"an uncertain event or set of events which, should it occur, will have an effect on the achievement of objectives. A risk consists of a combination of the probability of a perceived threat or opportunity occurring and the magnitude of its impact on objectives"* (M_o_R, 2010).

As it is evident, there is a strong emphasis in the M_o_R guideline on the organizational framework and management structure within which risk management takes place, echoing the priorities set in the

PRINCE2 guidelines for project management (Cooper, 2005). The guideline describes the risk management process, as illustrated in Figure 2-8, in the following manner:

- Identify: this process, dealing with identifying, consists of two main areas
    - Identify context: acquire information regarding the activity and the way it fits into the scope of broader organization focus, investigate and appreciate the purpose, extent, assumptions, limitations, stakeholders and context of the activity along with the applicable approach to risk management.
    - Identify risks: find and recognize the potential threats to the activity which may jeopardize the projected goals with the intent to reduce the threats and enhance the opportunities. It further involves documenting hazard and opportunities in the form of a risk register, selecting and justifying key performance indicators and early warning indicators, and appreciating the stakeholder's understanding of the risks.
- Assess: this process is also subdivided into two main areas
    - Estimate: investigate and understand the likelihood and the consequence of each risk. Immediacy – in terms of time – as to when the risk may physically materialize will also be taken into account. There are various risk assessment techniques outlined in the M_o_R guide, such as probability assessment, impact assessment, proximity assessment and expected value assessment.
    - Evaluate: with reference to the understanding of the degree of threat faced by considering both individual and aggregate impact of the risks, evaluation is performed. M_o_R guide offers a variety of evolution techniques, such as summary risk profiles, summary expected value assessment, probability risk models, probability trees and sensitivity analysis
- Plan: this process deals with preparing precise management actions to counter and exploit the known threats and opportunities respectively. The process involves finding and preparing responses to each risk, nominating an owner for each risk who will take full responsibility for managing it, nominating an action-taker for each risk who, under the supervision of risk owner, will take necessary measures to counter the risk, updating risk information in the Risk Register, and producing and supporting Risk Response Plans.
- Implement: this process deals with ensuring that the prepared risk management plans are executed properly and that the projects goals are achieved from the said execution. Corrective action should be taken to update and modify the plans where the responses are not meeting the expectations.

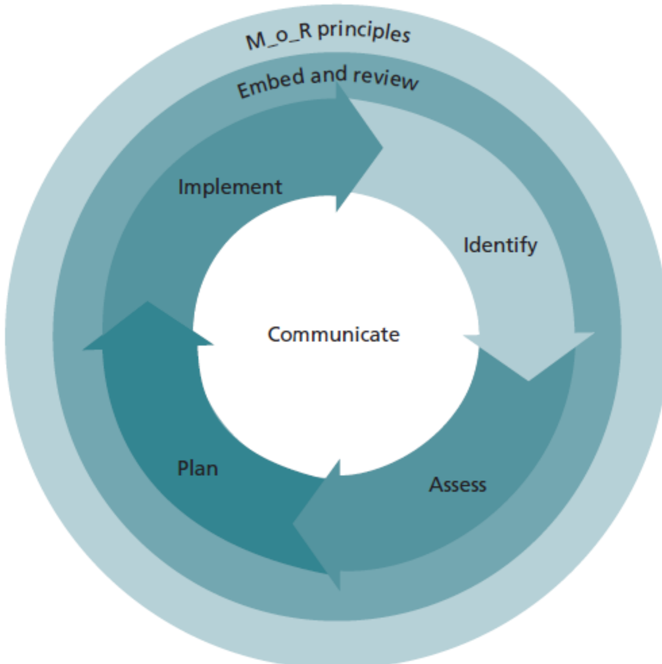

Figure 2-8: Risk management process according to M_o_R

It is worth mentioning that effective communication throughout the process is considered to be essential for ensuring the conformance and adherence of the process with the policy, strategies and plans.

M_o_R and AS/NZS 4360 are less task-oriented than the other approaches, being more concerned with high-level process requirements. Although all these approaches have their benefits and shortfalls, it can be safely deduced that they all follow the similar core principles of management which are undoubtedly based on pure logic. Cooper (2005) has revealed striking similarities between the processed offered by these approaches, as illustrated in Figure 2-9.

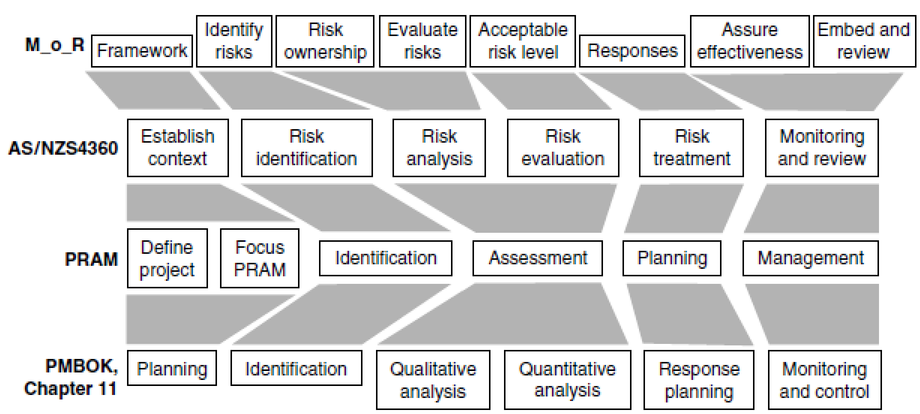

Figure 2-9: Risk management processes according to various approaches

Keeping in view its proximity with the core theories of project management and its range coupled with formalization of processes, it can be argued that the approach provided by PMI is so far the optimum of all. Part of the reason behind PMI's global success may be its outreach; however its sophistication, applicability and robustness cannot be emphasized enough. Therefore more PMPs are found today compared to other contending certifications of similar nature.

2.4: STRATEGIES FOR RISK MANAGEMENT

The selection of a strategy for managing the risk depends on several factors: typology of risk, resources available, management cost, severity of the impact and the likelihood of risk probability.

The risk, in analytical terms, is quantified as follows:

$$R = P \times I$$

Where:

"P" is the likelihood that an event will occur. The classical example is flipping a coin; there is 0.5 probability of getting head or tail on the flip. Note that the probability is expressed as a number from 0 to 1. Probability equals 0 means that there is no probability of the event occurring, as well as probability equals 1 means that there is 100% certainty the event will occur. Events with such outlying probability are never considered as risk.

When there is not a data register for the event, determining risk probability can be difficult because it is most commonly accomplished using expert judgment. Probability may be distributed continuously or discretely. Also there are normal and other probability distributions which illustrate the mean, mode and range of frequency with which a risk has (or is supposed to) occurred.

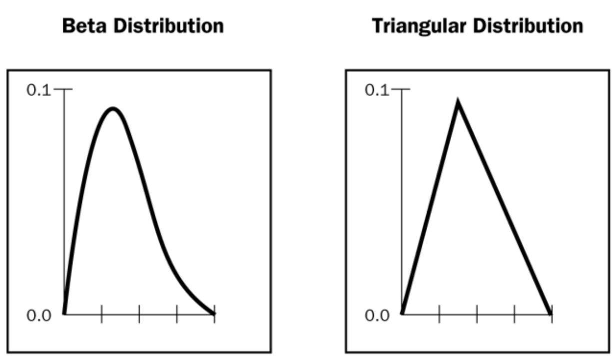

Figure 2-10: Beta and triangular distributions are frequently used in quantitative risk analysis

In the Figure 2-10, horizontal axes represent possible values of cost or time; and vertical axes, the relative likelihood. Other commonly used distributions are uniform, normal, and lognormal.

"I" is the amount of pain (or amount of gain) the risk event poses to the project. Table 2-2: Definition of impact scales for Cost objective according PMBOK shows the scale proposal of the PMBOK for impacts, according to the different objectives, such as cost, time, quality, and scope.

Project Objective	**Very low/0.05**	**Low/0.10**	**Moderate / 0.20**	**High /0.40**	**Very high / 0.80**
Cost	Insignificant cost increase	< 10% cost increase	10-20 % cost increase	20-40% cost increase	>40% cost increase

Table 2-2: Definition of impact scales for Cost objective according PMBOK

It is practically impossible to manage and respond to all potential risks, because it will result in an excessive use of time, money and resources. In short, unlimited amount of resources is never available to tackle all the identified risks. In this situation, it is important to classify the risks in order to manage them properly. It is the prerogative of the organization – dictated by organizational culture, behavior and impeding scenarios – to determine which combinations of probability and impact result in a high, moderate and low risk.

Probability	**Threats**				
0.90	0.05	0.09	0.18	0.36	0.72
0.70	0.04	0.07	0.14	0.28	0.56
0.50	0.03	0.05	0.10	0.20	0.40
0.30	0.02	0.03	0.06	0.12	0.24
0.10	0.01	0.01	0.02	0.04	0.08
Impact	0.05	0.10	0.20	0.40	0.80

Table 2-3: Probability and Impact Matrix according PMBOK

A "Probability and Impact Matrix", as the one that is shown in Table 2-3: Probability and Impact Matrix according PMBOK

, establishes the regions of high, moderate and low risk based on the corresponding combinations of probability and impact. Finally, it is important to underline that the opportunities and threats can be handled in the same matrix, always using the appropriate definitions for the levels of impact.

According to Snyder (2006), for positive risks (opportunities), the possible responses are to exploit the opportunity and use it, share the opportunity with someone who can take advantage of it happening and the impact if it does happen, or simply accept it. For negative risks, the possible responses are to avoid the risk, mitigate the risk or accept the risk. The diagram in Figure 2-11 will assist the decision makers in decreeing for the response to pursue with respect to the risk probability and impact.

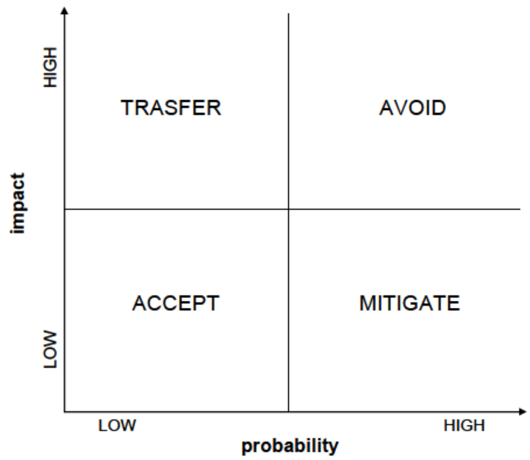

Figure 2-11: Main types of risk control action

- Avoid the risk: It involves making a change to the project or to the product that gets rid of the risk. For example, let us say that a project is planned to use a new suite of software tools, and the lead software engineer has identified a risk that the testing phase will not be completed on time because the testing staff is unfamiliar with the new testing suite. One option may be to test using the prior tool, which avoids the risk. Whenever possible, it is advised to avoid risks that have a high impact and high or medium probability.
- Mitigate the risk: It means reducing the probability that the risk will occur, reducing the impact that it will cause if it does occur, or both of these. In the previous example, for instance, some staff can be sent for training on the new software or parallel tests can be run with the old system and the new system. Another option is to allow for more time with the testing process.
- Transfer the risk: It seeks to relocate the consequences (and thus the ownership and responsibility) of a risk to a third party. Shifting the risk simply puts the other party in charge of its management; however the risk still remains in the project fold, only its ownership is delegated. Transferring the risk almost always involves the payment of a risk premium to a third party, in the form of insurance, performance bonds, warranties, and guarantees. Contractual arrangement may

also be set up to delegate the liability for specified risks to another party who is willing and competent enough to manage it.

- Accept the risk: It is a technique which implies that project team is ready willing to accept and tolerate the consequences of a risk without modifying the project plant. It may also suggest that no willing and competent third party was found or lack of a suitable response strategy (alternative plan). The acceptance could be active or passive (Lee, 2004): active acceptance may include a preemptive action plan, in the form of contingency budget, to counter the risk; whereas passive acceptance implies a reactive approach where no upfront actions are taken until risk is materialized and is mitigated later on.

A second set of strategies, used in the PRAM Guide, is based on the strategies of the PMBOK but with some particularities that give major details of the available strategies spectrum (Barlett, 2004). They are divided into threats and opportunities, as follows:

Threats:

- Avoid the risk by changing the objectives or the practices in use. In this way, the risk can be excluded from its source.
- Reduce the probability by preventing actions more than mitigation, whose implementations depend on the cost-benefit analysis.
- Reduce the impact through the use of either proactive actions or reactive ones. The first ones tend to maintain the flexibility of the project. The reactive actions focus on limiting the consequences following the occurrence of the risk event.
- Fallback refers to an action plan to implement in the case the risk event becomes unacceptable.
- Accept the risk in the case it is not economically optimum to manage the risk given its low impact and low probability, eliminate or reduce the risk.

Opportunities:

- Exploit the opportunity in a way to bring economic benefit to the stakeholders.
- Enhance probability by the implementation of proactive actions (strategic or operational).
- Enhance the impact by proactive and reactive actions for major risk control.
- Realize the opportunity in order to take advantage of the possible opportunities.
- Invest if the opportunity represents a good benefit, the stakeholders could take advantage of these positive events.

Common strategies for threats and opportunities:

- Transfer and share contractually: The transfer passes on the responsibility to third parties. But commonly, this responsibility is shared by the main parties of the project.
- Pooling: When is preferable to self-manage the risk instead of acquiring a financial protection on the market (e.g. insurance).

The third and last set of strategies is the one proposed by the UK Treasury's The Orange Book (HM Treasury, 2004). It is divided according to threats and opportunities, as follows:

Threats:

- Tolerate: The threat may be bearable without taking any further action. Even if it is not bearable, any response may seem inconsistent and uneven with respect to the potential profit secured. In such a scenario, the reaction may involve enduring the present level of risk. However, this alternative may be supported and enhanced by contingency planning for responding to the consequences in case the risk occurs.
- Treat: This is the most widely implemented strategy for risks, which aims at handling and controlling a risk and bringing its potential consequences to an acceptable level all the while keeping it internalized within the organization and maintaining the ownership.
- Transfer: Since organization cannot tolerate or treat all the identified risks, it becomes necessary to nominate some willing and competent third party to take the burden of risk. The instruments, ranging from conventional insurance to contractual agreements, help are shifting the burden, responsibility and ownership of risk. This option is particularly attractive for financial risks. It is also important to prudently establish the context and nature of relationship with the third party in order to avoid any future complications and legal problems.
- Terminate: Some risks may be of so devastating nature that the very activity (or set of activities) associated with that risk will need to be terminated in order to treat or contain to acceptable levels. However, this poses sever intimidation on development programs and their expected outcomes. This implies that terminating the activity is not a likely option for most of the projects, for example the public sector development cannot be constrained by such policy no matter how serious the associated risks are owing to the urgency and significance of these projects for the public benefit. However, this option can be of particular interest for project management when it

is conclusively established that the project cost/benefit relationship is swaying unfavorably for the stakeholders.

Opportunities:

- Take the Opportunity: Seizing the opportunity must not be considered as an alternative to the above mentioned strategies. It is more of a companion strategy which needs to be pondered into alongside tolerating, transferring or treating a risk. This entails two different perspectives: whether or not while mitigating threats an opportunity may arise to be exploited; whether or not such circumstances may surface which exclusively offer beneficial opportunities.

A summary of these risk management strategies is illustrated in Table 2-4: Summary of risk management strategies according PMBOK, PRAM and HM Treasury.

	PMBOK	**PRAM**	**HM Treasury**
Threats	Avoid	Avoid	Terminate Treat – directive controls
	Mitigate	Reduce probability Reduce impact Plan fallback	Treat - preventive Controls Treat - detective Controls
	Transfer	Share contractually Pool Insure	Transfer
	Accept	Accept	Tolerate
Opportunities	Exploit	Exploit	Take
	Enhance	Enhance probability Enhance impact Plan option Invest	
	Share	Share contractually Pool	
		Reject	
Contingent responses	Contingency planning	Reactive fallback Realize opportunity	Treat – corrective Controls

Table 2-4: Summary of risk management strategies according PMBOK, PRAM and HM Treasury

2.5: RISK ATTITUDES

A sizeable literature already exists on the study of risk attitudes from academic and organizational points of view. Concisely, it is an established line of argument that the risk attitudes exist on a continuum (Figure 2-12); the two extreme states are called “risk aversion”, individuals who consider risk as undesirable event, which must be dreaded and avoided, and “risk seeking”, individual who welcome risk, see it as challenging force which needs to be subdued. There is also a space between the two common positions, “risk tolerance”. A *risk tolerant* individual walks the middle road with an attitude of accepting the risk, considering it as part of routine life.

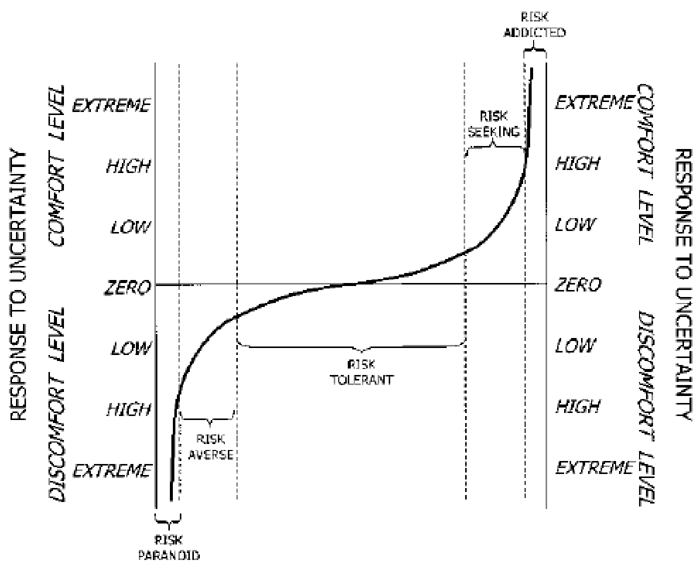

Figure 2-12: Spectrum of risk attitudes, Source: Hillson, 2004

Based on their attitudes, different individuals behave differently in similar scenarios. Risk averting individuals are considered to be oversensitive and aware of threats looming around them, whereas the risk seeking individuals underestimate the importance of these threats. Their actions, in accordance with their attitudes, also vary. A description, as illustrated in Table 2-5: Effects of risk attitudes, explains effects of risk attitudes.

	Risk Averse	Risk Tolerant	Risk Seeking
Attitude toward threats	Oversensitive and aware	Unconcerned	Underestimate importance
Actions toward threats	Aggressively avoid/minimize	None	Accept or ignore
Attitude toward opportunities	Under sensitive and unaware	Unconcerned	Overestimate importance
Actions towards opportunities	Under react or ignore	None	Aggressively exploit/enhance

Table 2-5: Effects of risk attitudes

Country	UAI Score	Country	UAI Score
Greece	112	Equador	67
Portugal	104	Germany	65
Guatemala	101	Thailand	64
Uruguay	100	Iran	59
Belgium	94	Finland	59
Salvador	94	Switzerland	58
Japan	92	West Africa	54
Yugoslavia	88	Netherlands	53
Peru	87	East Africa	52
France	86	Australia	51
Chile	86	Norway	50
Spain	86	South Africa	49
Costa Rica	86	New Zealand	49
Panama	86	Indonesia	48
Argentina	86	Canada	48
Turkey	85	U.S.A.	46
South Korea	85	Philippines	44
Mexico	82	India	40
Israel	81	Malaysia	36
Colombia	80	Great Britain	35
Venezuela	76	Ireland	35
Brazil	76	Hong Kong	29
Italy	75	Sweden	29
Pakistan	70	Denmark	23
Austria	70	Jamaica	13
Taiwan	69	Singapore	8
Arab countries	68		

Table 2-6: Uncertainty Avoidance Index (UAI) by country/region, Source: Hofstede (1982)

Hofstede (1982) characterized high-UAI (Uncertainty Avoidance Index) states with a higher anxiety level; people in these countries seem more preoccupied with the concerns of their future. These individuals resist change and seem to seek consensus early on, which pushes the fear of failing into them and thus they tend to commit to the hierarchical structures; "Latin cluster" in the words of Hoftede called the "Latin cluster", containing Italy, Venezuela, Colombia, Mexico, and Argentina, shows such traits. In contrast, low-UAI countries, "Anglo cluster" in the words of Hoftede, including Great Britain, USA, Canada, Ireland, Australia, New Zealand, South Africa, India and Philippines, seem to demonstrate a lower level of anxiety. Individuals in these states appear ready and prepared to take life on daily basis, displaying rampant adhocism. These individuals embrace and crave change and do not mind bypassing the hierarchy, thus the recognition and value of competition and conflict is properly appreciated. The details are illustrated in Table 2-6: Uncertainty Avoidance Index (UAI) by country/region, Source: Hofstede (1982).

2.6: SUPPORT ELEMENTS TO THE PROJECT RISK MANAGEMENT

According to the steps of the risk management process in the PMBOK (PMI, 2008a), the tools and techniques for project risk management could be organized categorizing the steps used in the Risk Management Process (shown in the Figure 2-13). In this way, we are going to focus our attention on the tools and techniques for the following processes:

- Risk Identification.
- Qualitative Risk Analysis.
- Quantitative Risk Analysis

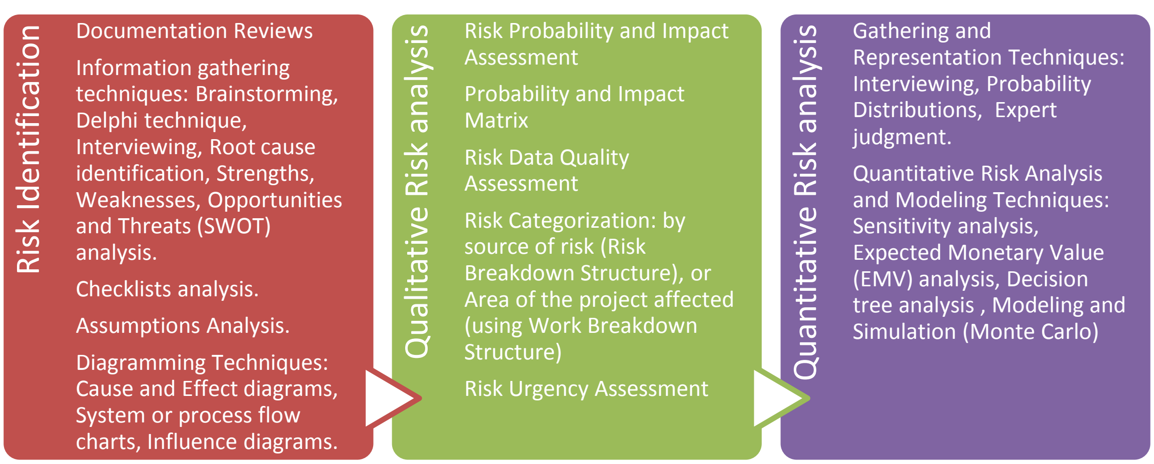

Figure 2-13: Principle tools and techniques in the risk management process

2.6.1: Risk identification tools and techniques

Documentation reviews

Structured review: project teams perform an organized review of project plans and postulations, both at the total project and detailed scope levels during the initial stages of the project. It also involves reviewing prior project files and other relevant information which may help in setting the context.

Information and Gathering techniques:

Brainstorming: the widespread utility of brainstorming for identifying risks is conclusively established. Its purpose is to extract an all-inclusive list of risks that can be analyzed later in the processes. It is usually performed keeping in mind the structure and organization of stakeholders, however all parties are represented offering a multidisciplinary, which helps in containing the biases. In order to counter the groupthink, a facilitator is nominated which moderates and mediates the activity. He/she invites the participants to generate ideas about possible project risks. Sources, causes, origins and bases of risk are categorized in comprehensive range and announced for everyone to discuss and inspect during the meeting.

Delphi Technique: it is a consensus-building technique used by experts to reach an agreement during the risk identification process. It also aims at more effectively countering the groupthink problem by keeping anonymity among the participants, which also reduces the chances of bias. Ideas are sought under the supervision of a facilitator who uses a questionnaire for this purpose. Each individual submits his/her responses which are then circulated amongst other participants for further comment. No open discussions are done. It is possible to reach the agreement on the main project risks in a few rounds of this process. The Delphi technique is useful for reducing the bias in the data and avoids an individual gaining unwarranted influence on the outcome.

Interviewing: in order to recognize, characterize and classify risks, experienced project managers and experts of the field may be invited for personal interviews. The owner of risk identification process is required to nominate these experts, who are further briefed and instructed regarding the context of activity. Other relevant information, such as project charter, scope of work, profile details, WBS, etc. may also be furnished in order to ensure more informed and better information gathering. These experts, in the light of their experience and shared information of project, identify risks.

Strengths, weaknesses, opportunities, and threats (SWOT) analysis: the purpose of this analysis is to study the project from a holistic point of view, a 360° prospect, which ensures comprehensive understanding of each of the SWOT perspectives in order to increase the breadth of the risks considered.

Checklists

Checklists aim at identifying risk; these are compilation of historical and established information regarding risk in the similar contexts, fields and areas. It helps in rapidly and easily identifying and classifying project risks. However, due to the limitation of preparing thorough and all-inclusive checklist of risks, risk identification has to rely on the previously published data. Novelty of information is something checklists do not seems to embody unless influenced by the industry. Therefore, it is imperative to further explore risk items which are not available in the standard checklists. The checklist must enumerate and classify all types of possible risks affecting the performance of a project in order to comprehend the description of potential risks.

Assumptions analysis

Before a project is launched, the rampant uncertainty enforces the prime stakeholders to introduce into project some hypotheses, scenarios or assumptions in order to better conceive and develop it. Assumptions analysis is a technique which aims at probing into the validity of these assumptions. This analysis may help in risk identification by investigating the accuracy, consistency and totality of these assumptions.

Diagramming techniques

Cause-and-effect diagram: the cause-and-effect diagram helps identifying causes of various risks by providing an insight into the risk resource. It is also known as Ishikawa or fishbone diagram.

System or process flow charts: these flow charts show the causal relationships between various actors/activities and provide an insight into the phenomenon of emergent risks, as causation is at the core of this analysis.

Influence diagrams: here also the causal influences are graphically represented to help understand their apparent impact. The events are time-sequenced.

2.6.2: Qualitative risk analysis tools and techniques

Risk probability and Impact Assessment

As part of qualitative assessment, it is possible to describe likelihood and resulting impact of the risk in descriptive terms, such as “very high”, “high”, “moderate”, “low”, and “very low”. It is imperative to mention here that these qualitative rankings are subjective in their nature. The likelihood of the risk refers to the chance of occurrence, in terms of probability percentage from 1% to 99%. If the risk occurs, the resulting impact or consequences refer to the aftermath on the project objectives. Likelihood and impact are private to each risk and their cumulative effect needs to be studied as well. This kind of analysis screens out the most hazardous risks which need aggressive management.

Probability/Impact risk rating matrix

This qualitative technique uses a matrix in order to assign risk ratings based on the probability and impact combinations. Being a qualitative analysis, the rankings or scales are descriptive and subjective, such as "very low", "low", "moderate", "high", and "very high". More serious risks, which have a combination of higher likelihood and impact, will need further analysis as well as serious and aggressive management.

Theoretically, the likelihood of a risk may fall between 0% and 100%, former referring to absolute certainty of non-occurrence and latter indicating the absolute certainty of occurrence. Excluding these outliers, practically the risk probability lies between 1% and 99%. It is challenging to assess the risk probability as most often expert judgment is utilized to obtain this information, usually without referring to historical data. Semi-quantitative transformation may also be done in the form of an ordinal scale, representing relative probability values from very unlikely to almost certain. Alternatively, specific probabilities could be assigned by using a general scale (e.g., .1/ .3/ .5/ .7/ .9).

Project Objective	Very low/0.05	Low/0.10	Moderate / 0.20	High /0.40	Very high / 0.80
Cost	Inconsequential cost escalation	< 10% cost escalation	10-20 % cost escalation	20-40% cost escalation	>40% cost escalation
Time	Minor time increase	< 5% time rise	5-10% time rise	10-20% time rise	> 20% time rise
Scope	Scope reduction hardly visible	Slight scope changes	Major scope changes	Scope decrease undesirable for owner	Project end item is effectively useless
Quality	Quality decline hardly visible	Only very challenging applications are disturbed	Quality decrease needs owner agreement	Quality decrease undesirable to owner	Project end item is effectively useless

Table 2-7: Definition of impact scales for four project objectives according PMBOK

The scale of risk impact indicates the gravity of its consequences on the project objectives (Table 2-7: Definition of impact scales for four project objectives according PMBOK shows an example of impact ranking in terms of the project scope). Impact can be expressed in ordinal or cardinal manner, depending upon the organizational culture and behavior. Ordinal scales specify the order of things in a set—first, second, third, etc.; they do not show the quantity but only the rank, position or even degree, such as very low, low, moderate, high, and very high. Cardinal scales, on the other hand, nominate numerical values to these consequences. These numbers often are linear (e.g., .2/ .4/ .8/ .6/), but can also be nonlinear (e.g., .02/ .2/ .22/ .44/ .7) pointing towards the desire of the organization to circumvent the high-impact risks. The purpose of the two methods (ordinal or cardinal) is to allot relative value scales which can be further exploited using set definitions in accordance to organizational culture and behavior (Lee, 2004). These definitions refine the data quality and help repeating the process. A probability impact (PI) matrix, illustrated in Table 2-8: Probability and impact matrix according PMBOK

, displays the simple multiplication of the estimated values of probability and impact in order to establish the final severity of the risk.

Probability	Threats					Opportunities				
0.90	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05
0.70	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04
0.50	0.03	0.05	0.10	0.20	0.40	0.40	0.20	0.10	0.05	0.03
0.30	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02
0.10	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01
Impact	0.05	0.10	0.20	0.40	0.80	0.80	0.40	0.20	0.10	0.05

Table 2-8: Probability and impact matrix according PMBOK

Risk categorization "Risk Breakdown Structure" (RBS)

In theory, an extremely generic and top-level RBS can be constructed which can be applicable to any project. But such a global risk breakdown structure is limited at a number of fronts; it might not encompass the entire scope of all the risks the project may be exposed to. Therefore, it becomes imperative for organizations to customize the generic RBSs in order to make it appropriate and fit for their needs (Hillson, 2004). Further, personalized RBSs can also be constructed for large, novel and complex projects due to their inherent properties.

Table 2-9: Typical risk breakdown structure (RBS) exhibits a typical RBS, which shows the risk sources at the level 0. Moving down the structure, major sources of risk are enumerated and further classified. The trend of going deeper and offering more details continues till we reach the last level, which are actual risk items. The risk items need further analysis, responding, monitoring and control.

RBS for Generic Project (Hall & Hulett, 2002)

LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3
Project risk	Management	Corporate	History/experience/culture
			Organisational stability
			Financial
			...etc...
		Customer & stakeholder	History/experience/culture
			Contractual
			Requirements definition & stability
			...etc...
	External	Natural environment	Physical environment
			Facilities/site
			Local services
			...etc...
		Cultural	Political
			Legal/regulatory
			Interest groups
			...etc...
		Economic	Labour market
			Labour conditions
			Financial market
			...etc...
	Technology	Requirements	Scope uncertainty
			Conditions of use
			Complexity
			...etc...
		Performance	Technology maturity
			Technology limits
			...etc...
		Application	Organisational experience
			Personnel skill sets & experience
			Physical resources
			...etc...

Table 2-9: Typical risk breakdown structure (RBS)

The function of RBS is to provide an insight into the sources of risk, whereby giving a perspective of common causes of project risk. This allows project teams to be more conscious and prudent towards certain causes which pose major threat to project activities. It is also possible – and sometimes necessary – to figure out the part of project, activities in short, which are most problematic; which means more risks are associated to them. For obtaining this critical information, a matrix of RBS and WBS (work breakdown structure) is formed, crisscrossing the activities and risk items, showing associations and impact. This investigation helps singling out the parts of project which are most vulnerable to recurring risks and the most challenging risk items as well. Figure 2-14 illustrates a typical WBS-RBS matrix.

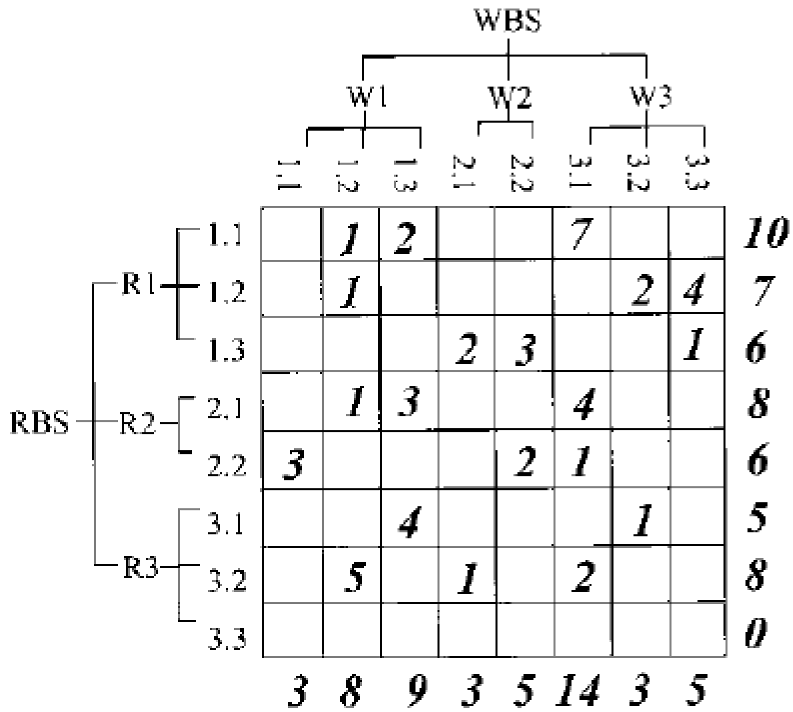

Figure 2-14: Correlating RBS with WBS

Project assumptions testing

It is imperative to assess the assumptions which are utilized in the project. Because if the assumptions are not based on solid logical and analytical grounds, their very foundation becomes uncertain and, hence, the cumulative effect may be disastrous. The assumptions need to be tested against two criteria: their stability and the impact on project objectives in case of incorrectness. As a precautionary measure, similar correct assumptions that must be identified and their impact on the project must be tested.

Data precision ranking

For any data to serve its purpose and be useful, its precision and impartiality are of paramount importance. In order to check the precision of data, data precision ranking technique is used which evaluates the degree of usefulness for the purpose of risk analysis. Degree of risk understanding must be studied as part of this ranking. Also the availability of data along with its quality, reliability and integrity need to be pondered into before it can be used for analysis.

In case a low precision data is used, the ultimate value addition for qualitative risks analysis is really questionable. In such cases, it is advisable to look for other data of better quality.

2.6.3: Quantitative risk analysis tools and techniques

Quantitative risk analysis inputs

Organizational Process Assets: it refers to the information on prior and similar past projects studied by the risk specialists along with commercial or academic risk databases.

Project Scope Statement: this statement aims at recording the project objectives, deliverables, and the work which will go into producing them for diverting the efforts of project team to finalize future project resolutions (Heldman, 2009).

Risk Management Plan: it documents the key elements for the qualitative risk analysis. The usual contents of this plan may include roles and responsibilities, budgets, schedule activities, risk categories, the RBS, and risk tolerances.

Risk Register: it contains the list of identified risks, relative ranking or priority list of project risks and the risk classified into specific categories.

Project Schedule Management Plan: it establishes the setup and determines the conditions for preparing and controlling the project agenda.

Project Cost Management Plan: it establishes the setup and determines the conditions for preparing, structuring, estimating, budgeting and controlling the cost of the project.

Interviewing

This technique is employed to determining the likelihood and impacts of risk scenarios on project objectives in quantitative scales. A risk interview may be organized with the prime actors and experts in order to pick their minds for quantitative results. Probability distributions which are used for analysis will influence this information and therefore must be communicated to the interviewees upfront. The said influence may materialize such as optimistic (low), pessimistic (high), and the most likely risk scenarios may be obtained if using triangular distributions, or mean and standard deviation in case of the normal and log normal distributions.

It is expected of a good project manager to know 60-80% of project risks, as displayed in Figure 2-15. This is due to his knowledge of project charter and/or business case, its aims, limitations, assumptions and the overall organizational context within which the project functions. This number (60-80%) is estimated based on the experience of some risk practitioners (Hillson, 2004).

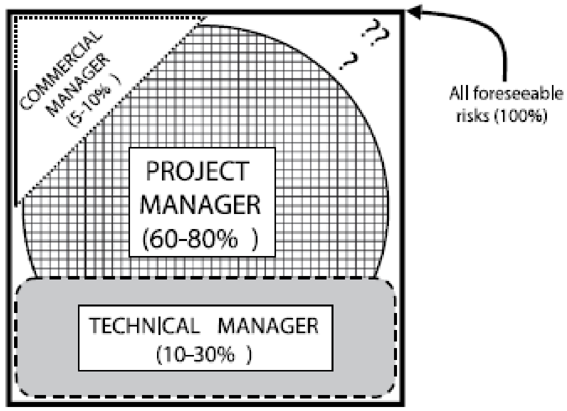

Figure 2-15: Scope of risk exposed during interview, Source: Hillson, 2004

Probabilistic distributions

Commonly used probability distributions for quantitative risk analysis are continuous probabilistic distributions (particularly beta and triangular distributions). According to the PMBOK, normal, lognormal, triangular, beta, and uniform distributions are included in continuous probability distributions. Distributions are graphically displayed and represent both the probability and time or cost elements.

Triangular distributions use estimates based on the three point estimate (the pessimistic, most likely and optimistic values). This means that during the interviews, these pieces of information will be gathered. Then, it is needed to quantify the risk for each WBS element.

Normal and lognormal distributions use mean and standard deviations to quantify risk, which also require gathering the optimistic, most likely and pessimistic estimates (Clemen and Winkler, 1999).

Expert judgment

Experts come from inside or outside the organization and should have the experience that is applicable to the project. For example, if the project involves manufacturing a new product or part, you might want to consider experts such as engineers or statisticians. If you are dealing with sensitive data in an information technology project, consider bringing on a security expert (Otway and Winterfeldt, 1992).

2.6.4: Quantitative risk analysis and modeling techniques

Four techniques are encompassed here: sensitivity analysis, expected monetary value analysis, decision tree analysis, and modeling and simulation. Given below is a brief description of each.

Sensitivity analysis

Sensitivity analysis is a quantitative technique of assessing the possible consequences of risk on the project. Not only this, it goes one step ahead by determining which risks post greatest threat by comparing the uncertain elements with their established baseline values. Usually tornado diagram is used to graphically represent sensitivity analysis data, as shown in Figure 2-16, (Heldman, 2009).

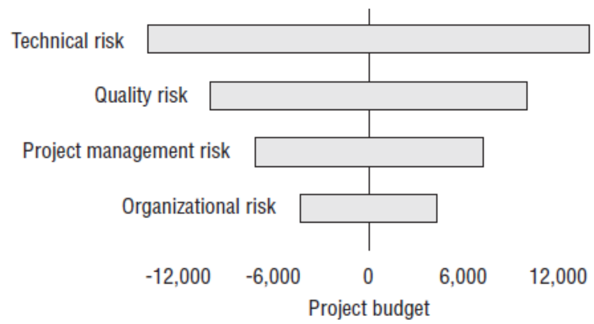

Figure 2-16: Tornado diagram

In the Tornado Diagram, each bar represents a sensitive variable, representing the low and high values for that element. In this way, the variables with the greatest effect on the project appear at the top of the graph and decrease in impact going down. Tornado Diagram can be used to represent cost, time, and quality objectives (Eschenbach, 1992).

Expected monetary value (EMV)

Expected monetary value is a statistical technique which aims at estimating the mean expected consequence of the decision. In order to compute EMV, risk probability is multiplied with its impact and a submission is done at the end. EMV is used in combination with the decision tree analysis technique. The interpretation of EMV is very easy; positive EMV indicates project opportunities, whereas negative EMV warns for project threats. EMV can also be used for calculating contingency budgets (Raftery, 2003).

Decision tree analysis

Decision trees are the event-series diagrams which illustrate the order of interrelated decisions and the expected results of selecting one over the other. Typically, more than one choice or option is available when you are faced with a decision or, in this case, potential outcomes from a risk event (Dey, 2002). The available choices are depicted on tree form from starting at the left with the risk decision branching out to the right as we move ahead with the possible outcomes. Decision trees are mostly used for risks associated with time or money. A typical decision tree is illustrated in Figure 2-17.

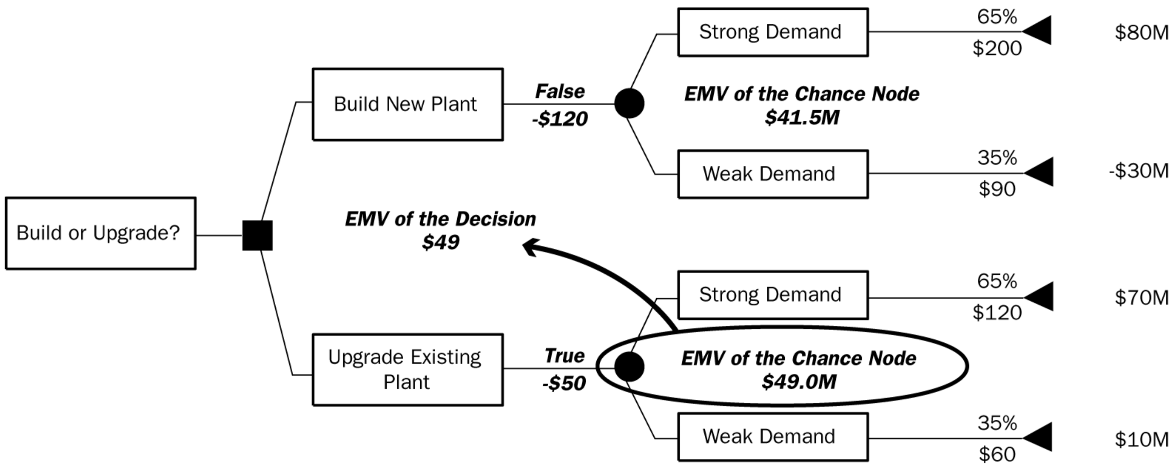

Figure 2-17: Decision tree diagram

Modeling and simulation

Modeling and simulation techniques are frequently relied upon for schedule and cost risk analysis. Modeling allows translating the potential risk at specific points in the project into their impacts so it is possible to determine how project objectives are affected. Simulation techniques compute the project model using various inputs in order to decide for a probability distribution for the control variable which is selected upfront. The inputs usually are cost or schedule duration. Cost risks typically use either a WBC or CBS as input variable. Schedule risks always use the precedence diagramming method as input variable.

Monte Carlo analysis is an example of a simulation technique. Monte Carlo is replicated many times, typically using cost or schedule variables. Every time the analysis is performed, the values for the variable are changed using a probability distribution for each variable (Vose, 1996).

Quantitative risk analysis outputs

Probabilistic Analysis of the project: the probabilistic analysis of the project includes the achievable completion dates and cost along with the associated levels of confidence. It is normally mentioned as a cumulative distribution and is used with risk tolerances of prime actors in the project for calculating cost contingency reserves and time contingency buffers. Such contingencies come into play when the project targets (in terms of time and cost) seem difficult to be achieved in the normal conditions. So in such conditions, resources from these reserves are utilized to bring to a level acceptable to the organization (PMI, 2008a). Figure 2-18 illustrates the probability of cost overrun, allowing to project organizations to define contingency budgets according to the level of certainty desired to estimate the total cost.

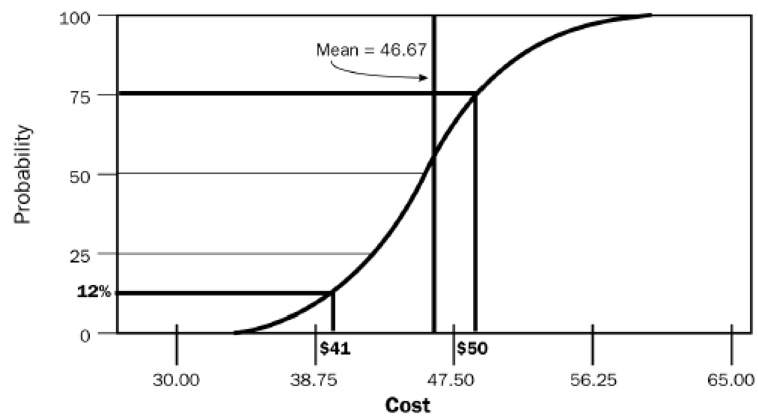

Figure 2-18: Cumulative likelihood distribution according to total cost of the project

Prioritized list of quantified risks: this list contains the most serious risks in both positive and negative terms, with highest possible impact to project objectives. It allows realizing the major threats and opportunities likely to be faced. These encompass those risks which compel for more cost contingency and those which may greatly affect the critical path.

Trends in quantitative risk analysis results: trend to the qualitative risk analysis are achieved by repeating the analysis and also can further be used as lessons learnt. These lessons form part of the experience and may be applied to similar future projects.

2.6.5: Risk monitoring and control tools and techniques

Project risk response audits

In order to verify the efficiency of risk responses, risk audits are carried out which aim at examining and recording the precedence of avoiding, transferring, or mitigating risk occurrence. Risk audits also take into account the efficiency of risk owner. Risk audits are carried out during the lifecycle of the project in order to better manage the risk.

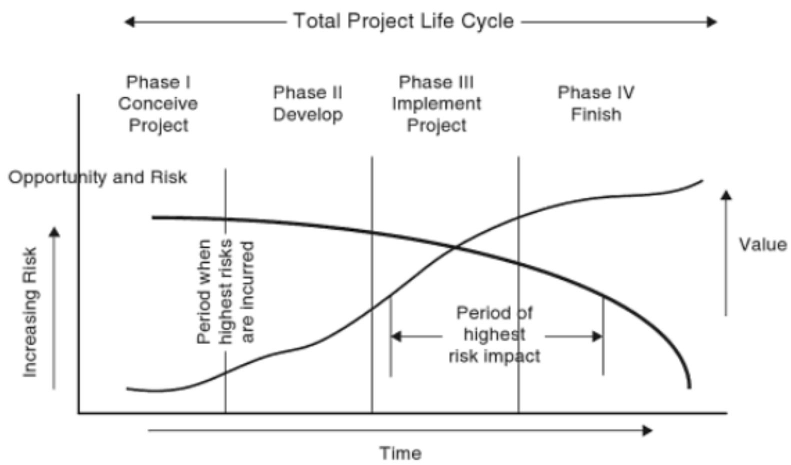

Figure 2-19: Risk and project lifecycle

Figure 2-19 shows the degree of riskiness during the project life. The project phases (Conception, Development, Implementation and Finish) form a typical project lifecycle and practically every project undergoes these phases. As evident from the figure, the initial project phases are always more risky owing to the rampant uncertainty, therefore the trend of risk (presence and discovery) declines as the project moves on in its lifecycle. However, with this progress, the resources at stake increase which pose constraints at many fronts. Therefore, with higher utility at stake in the later stages of the project, the impact or risk is highest.

Status meetings

It is imperative to frequently review the project risk so that any changes and fluctuations are observed early on in the process. These status meetings must address project risk as an important agenda. Details of risk may change during the course of project; such changes may need additional analysis and responding. All these items must be discusses and deliberated in the status meetings (Raz and Michael, 2001).

Earned value analysis (EVA)

In order to assess the performance of project activities and figure out any possible delays and cost overruns, earned value is used. It helps in monitoring the overall project performance and compares it against a baseline plan; the process is called earned value analysis (EVA) (Anbari, 2003). Results from an EVA are used to find out if the project will complete respecting and achieving the projected goals. EVA is useful in warning about the first signs of future troubles which a project might face. A typical EVA is shown in Figure 2-20. In case such warnings are realized and a project seems to significantly deviate from the baseline, it is important to update the risk profiles and perform revised analyses.

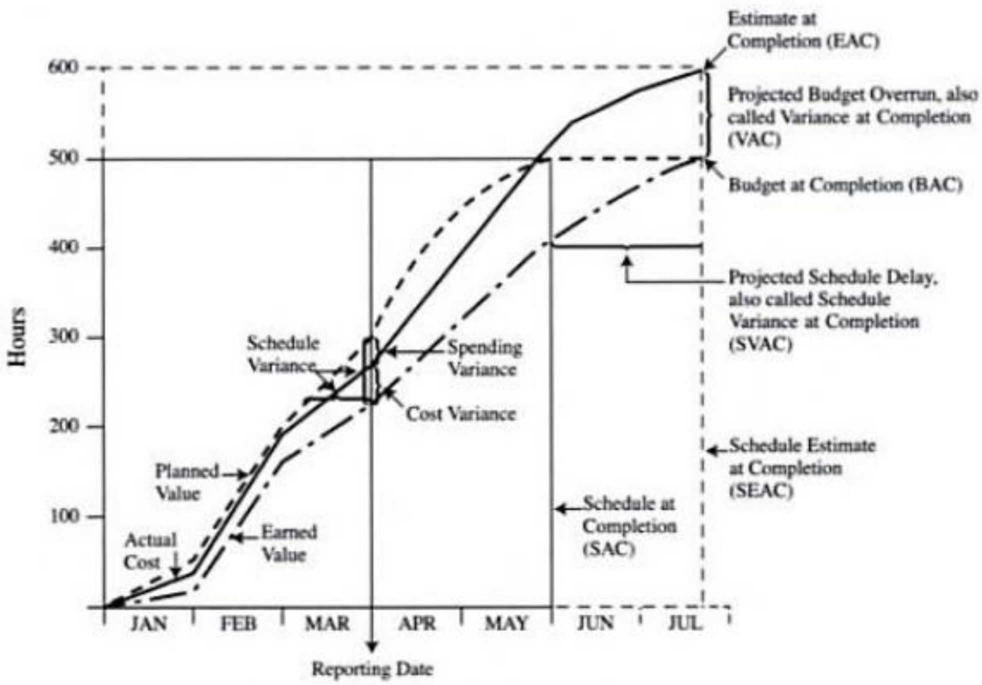

Figure 2-20: EVA chart

EVA is a mathematical technique, which operates on numerical data and compares your project execution to baseline plan (time and cost). EVA links project time to project cost in order to avoid any misleading interpretations of the project performance. For example, the project could be spending less than planned, but may be due to much less work being done. On the other hand, it could be ahead of schedule because there may be an overspending. EVA shows the actual progress in the project and helps to identify problems at an early stage (Vanhoucke, 2011).

Technical performance measurement

In order to compare the technical achievement made during the project execution with technical achievement schedule of project plan, technical performance measurements are made. Any deviations can indicate towards a risk hindering the successful accomplishment and execution of project plan. One such deviation may be not being able to demonstrate the functionality as scheduled at a milestone.

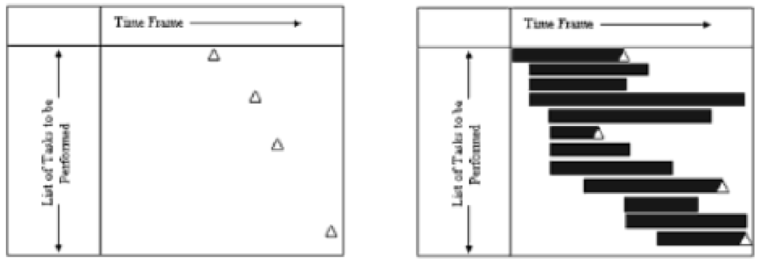

Figure 2-21: On the left is Milestone chat and on the right is Gantt/Milestone chart

As is shown in Figure 2-21, Gantt charts allow identifying and tracking your tasks. A Milestone is a major event in the life of a project. In the case of large projects, they can have many Milestones.

Additional risk response planning

It is quite possible to have risks which were not identified in the first place, or change in details (likelihood and impact) of previously analyzed risks. In such cases, it is imperative to perform additional risk response planning in order to actively manage such situations. On a risk continuum, such risks are termed as 'unknown-unknowns' and in order to manage them, management reserves are earmarked in the project plan.

Further, frequent risk reassessment must be built into the very core of project charter. Risk must be an important agenda item at regular status meeting (PMI, 2008a). This might mean a lot of redundant information; however the amount of suitable repetition is directly proportional to the conformity of project progress with project objectives.

Reserve analysis

It is quite logical that some risks will occur (with positive or negative consequences) during the project execution. This occurrence will affect the contingency reserves of both cost and schedule accounts. In order to monitor the project performance, reserve analysis is carried out which aims at comparing the outstanding amount of contingency reserves to the amount of residual risk at any time in the project. This helps in ensuring if the contingency reserves are enough and will last till the project completion (PMI, 2008a).

CHAPTER 3

SUSTAINABLE CULTURAL HERITAGE MANAGEMENT

Sustainable development is a buzzword of an increasingly significant stature in the contemporary times. It is officially defined as *"the development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*. The basic tenets of sustainability go hand in hand with the principles of natural balance and equilibrium in an apparently finite context, with predictably computable resources (Holmberg and Sandbrook, 1992). The notion of sustainable development in the realm of cultural heritage management, with specific attention to restoration activities, cannot only be supported by the introduction of PM and PRM but can also be strengthened. In simple words, active management of restoration projects and their risks can be considered as a very important step in the pursuit of sustainability.

3.1: GENESIS OF SUSTAINABLE DEVELOPMENT EFFORT

The well-known Brundtland Commission of 1987 is credited to have come with this formal definition which is the mantra of conservation, preservation and nature-sensitive faction of people, experts and laymen alike. The genesis of sustainability movement dates back to its origin in 18th century, after the Industrial Revolution. Owing to the exponential leap in betterment of people's life, the upsurge in population was evident. Thomas Malthus raised the question of geometric population growth in his *"Essay on Population"* in 1798.

In the English context, the economy was tightly bound with coal as it was the chief energy source. In 1865, William Jevons wrote *"The Coal Question"*, where he predicted that, based on the population growth, Britain's coal reserves will soon deplete and its economy will suffer. He was partially right but he failed to contemplate the use of other energy sources. Two lessons can be learnt from Jevons' predictions: hard and fast projections will probably be wrong; technology will attempt to solve any problem caused by misuse/abuse of resources. In the American context, Olmsted and Vaux developed Greensward plant in mid-1800's for an urban park, now known as Central Park in New York. Olmsted was involved in designing some of the most outstanding and enduring parks in the world during his 50-year career. He is widely regarded as the father of landscape architecture in US, with a special eye for sustainability concerns.

Leopold, in 1949, wrote that all ethics evolved till then rest upon a single premise: the individual is a member of community of interdependent parts. His instincts prompt him to compete for his place in that community but his ethics prompt him also to co-operate (perhaps in order that there may be a place to compete for). He believed that people need to view the natural world in terms of a biotic pyramid or ecosystem (as shown in Figure 3-1), defined by interconnected webs of relationships among soil, plants and animals.

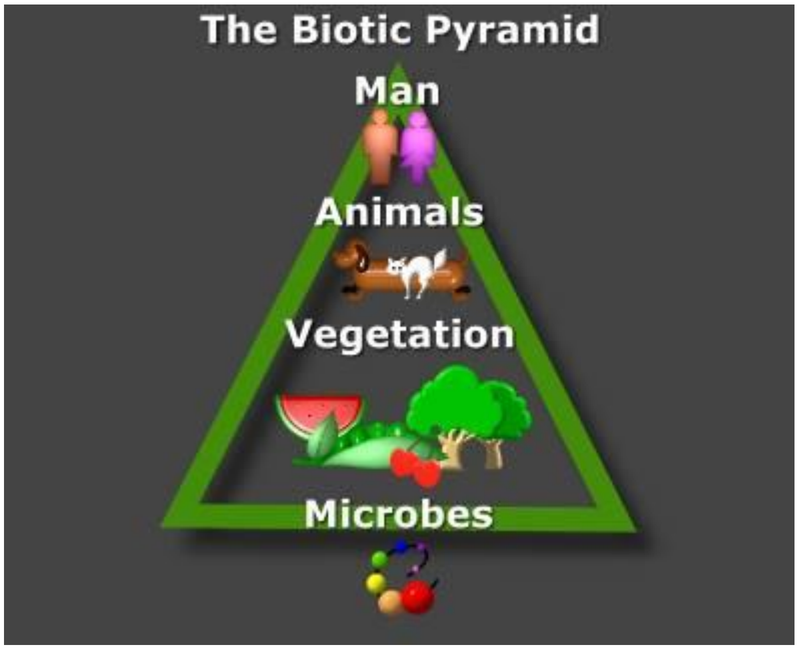

Figure 3-1: On Biotic pyramid of ecosystem

While Leopold was working on his thesis, American population was 125 million and the nation has just emerged from 'Great Depression' and 'Dust Bowl', far away from fertilizers and chemical industries of modern times. Afterwards, coming out of WWII gave an impetus to uncontrolled, hasty and haphazard growth, which was littered with consumerism practices so much so that the very survival of this growth was putatively based on consumption. Remembering this fancy postwar period (1945-1950's), Bryson wrote *"The Life and Times of Thunderbolt Kid"*, where he says:

> *"Happily we were indestructible. We didn't need seatbelts, air bags, smoke detectors, bottled water, or the Heimlich maneuver. We didn't require child safety caps on our medicines. We didn't need helmets when we rode our bikes, or pads for our knees and elbows when we went skating. We knew without a written reminder that bleach was not a refreshing drink and that gasoline when exposed to a match had a tendency to combust. We didn't have to worry about what we ate because*

> *nearly all foods were good for us: sugar gave us energy, red meat made us strong, ice cream gave us healthy bones, coffee kept us alert and purring productively."*

The increasing demand for food and the ever-lingering food-security issues gave raise to unhealthy and unfriendly environmental practices. The use of pesticides and fertilizers increased to alarming levels. Rachel Carson, who had written famous 'Sea' trilogy books, penned down *"Silent Spring"* in 1962. In this book, she took to task man's assaults upon the environment. She singled out contamination of air, earth, rivers and sea with dangerous and even lethal materials. She clarified her position of not being someone who is saying that there is no insect problem and does not need control. But she rather suggested that control must be geared to realities, not to mythical situations, and that the methods employed must be such that they do not destroy humans along with the insects.

Taking Carson's work further, Ian McHarg wrote "Design with Nature" in 1969. He suggested that a thorough and careful analysis of a site, before commencing the development activities, could enable the designers and stakeholders to develop areas mindfully, avoid destroying ecosystems, provide desired recreational opportunities and facilitate a sustainable tourist industry. The précis of McHarg's work is that built environment must be designed in harmony with the natural environment. He further stressed that entropy of the system must be counterbalanced with their negentropy.

In her famous book, *"Signs of Hope"*, published in 1990, the famous Norwegian politician – who has served three terms as Prime Minister of Norway – Gro Harlem Brundtland, talking about her other well-known and celebrated endeavor, ***Our Common Future***, also known as the Brundtland Report, from the United Nations World Commission on Environment and Development (WCED), said that it is a hard-won consensus of policy principle forming the basis for sound and responsible management of the Earth's resources and the common future of all its creatures.

This gives an insight regarding the evolution of fancy sustainable development definition that is contemporarily prevalent. This journey, which is roughly centralized around the Brundtland commission, not only stretches in the past but also goes ahead, as shown in Figure 3-2. The Kyoto protocol of 2005 may be considered as the latest development in this context.

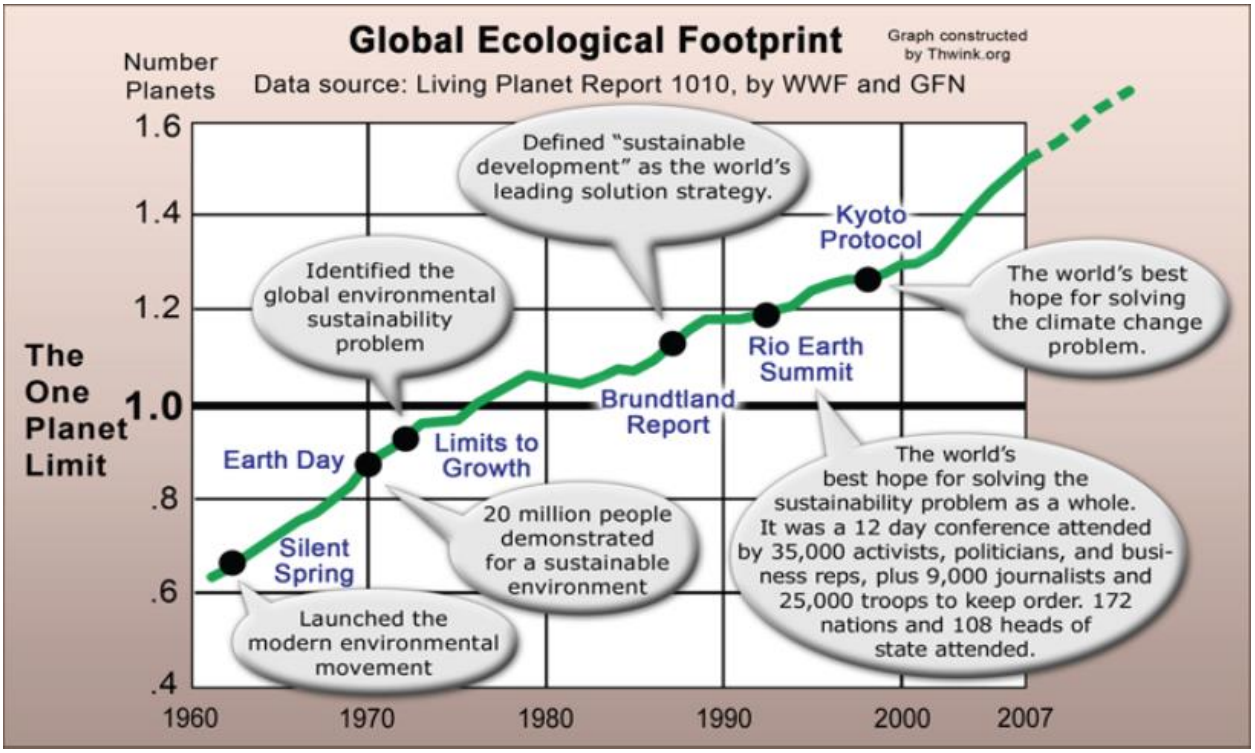

Figure 3-2: Evolution of sustainable development effort in modern times

3.2: PILLARS OF SUSTAINABLE DEVELOPMENT

It is paramount for understanding the sustainable development that its building blocks be understood; the pillars, as shown in Figure 3-3, on top of which the sustainability rests, though not necessarily mutually-exclusive, are competing with each other in their nature and allegedly in their purpose as well. A fair understanding of these fundamental domains ascertains the focus in the face of contending (and at times clashing) needs and resources.

Thus, at the core of sustainable development, there is simmering need to deliberate and reflect upon these best tenets mutually and collectively: society, the economy and the environment. Regardless of the application context, the basic philosophy remains unchanged: societies, environments and economies are all part and parcel of a complex web of intricate relationships and interactions. The relationship is so elastic in its nature that disturbing (or allowing to disorder) the natural order in one sector poses sometimes irreversible consequences in others.

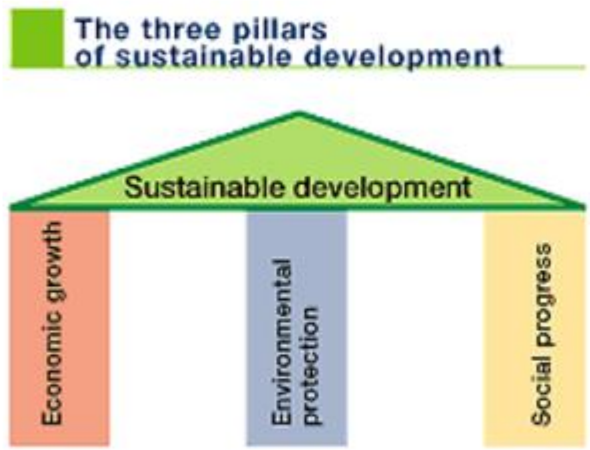

Figure 3-3: The three pillar of sustainable development

According to Adams (2006) in a report mostly knows as The World Conservation Union, 2006, the economy is an overriding factor in contemporary times, as illustrated in Figure 1-1. Although the theory warrants for an equal treatment to all the pillars, environmental concerns seem the most neglected of all. The much-needed change aims at increasing the gravity of environmental worry and making it equal to the other pillars. In the absence of such a change, the development cannot be called as sustainable.

Figure 3-4: Overlapping circles of sustainability

3.2.1: Society

The social pillar of sustainability is, simply put, people-centric. It imbibes the sort of value system which is at the core of social implications of development of any kind. It attempts to understand and estimate the impact of unsustainable growth and trends on community, its wellbeing and behavior as a whole (Tracey and Anne, 2008).

However, the social pillar of sustainability has traditionally been considered and recognized as the weakest pillar (Lehtonen, 2004). Aggravating the situation, a policy-level consensus on an agreed upon definition has not been materialized as yet largely due to a lack of consonance on the range of notion embodied inside the *'social'*. As a matter of fact, what characterizes the 'social' pillar is established by the fundamental theoretical framework. The social dimension is clearly different from the environmental one, since it is bipolar; it embodies both to individual and the collective interests; it is reflexive – our perceptions and interpretations of the objective social conditions change the behavior of individuals and social collectives, hence influencing the objective conditions themselves; and it is immaterial – while concrete material circumstances lie at the basis of the 'social', the social phenomena themselves are essentially immaterial and therefore difficult to grasp and analyze, in particular quantitatively (Empacher and Wehling, 2002).

As global citizens, it is every person's duty, whether an entrepreneur or en employee, whether a venture capitalist or an environmentalist, whether an industrialist or a labor, to take into account the social footprint of his/her actions, the wellbeing of people and the environment. It is everyone's ethical responsibility to do something about the human inequality, social injustice, and poverty. This pillar supports initiatives like peace, social justice, reducing poverty, and other grassroots movements that promote social equity (Meyer, 2000).

3.2.2: Economy

This is probably the most stressed upon feature of sustainable development. The rationale is built upon the past performance where economic benefit was accepted at the cost of social and environmental hazards. Thus the competing trend is at the core of neutralizing this strained relationship. The economic pillar of sustainability refers to the financial and commercial aspects of development. In this case, the stress is not upon making financial investment more profitable in terms of monetary return on investment but understanding the moral hazard[2] which goes in while making globally (un) sustainable decisions (Tracey and Anne, 2008).

With the ever-increasing demands for adopting the sustainable behavior, organizations are looking more into the performance governance solutions which are at the core of addressing these opportunities. Thus,

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[2] In economic theory, a moral hazard is defined as a managerial (or decision-making) situation where one party shows the tendency to take risk because the relevant costs that can eventually come up will not necessarily be borne by it. In simple words, this risk taking party will only yield the positive consequences and the negative ones (if any) is not its responsibility. Alternatively, it may also be defined as an inclination towards risk-seeking behavior, knowing that the potential costs or burdens of such decision will be borne, in whole or in part, by others.

organizations are turning to be more long-term goal setters and achievers where their corporate governance is more sustainable. At the top managerial level of organization, decision makers are seeking the backdrop of knowledge about their current operations so to be able to better identify the opportunities for significant change, optimal investments and apparent growth in sustainable manner (Kates et al., 2005).

3.2.3: Environment

It will not be an overstatement to say that the environmentalists pioneered and championed the cause of sustainable development. As mentioned in "Genesis of sustainable development effort", it can be conclusively established that the environmental concerns, though perceived exceedingly crucial, have usually and historically been compromised. There is a need for a sustainable economic model which safeguards interests of all stakeholders involved, warrants a just distribution and efficient allocation of mutually owned resources. This pillar ensures that our economic growth upholds and supports a healthy balance with our ecosystem (Tracey and Anne, 2008).

The impact of unsustainable consumption behavior has been dearly noticed in recent times. The undue reliance on the fossil fuels for energy purposes has resulted in severe depletion of these resources in the form all time low reserves (Panwar et al., 2011; Dincer, 2000). The withering environmental consequences in the form of global warming, increasing levels of GHGs, incomprehensible change in weather cycles, raise in sea levels, etc. are at the core of new environmental awakening, which aims at not only attempting to understand the changed behavior or ecosystem but also endeavoring to return to optimal levels. Although it is easier said than done, the global partnering and collaborating efforts are raising the awareness, educating the masses and inducing the need to think sustainably. The drive towards renewable energy is one such attempt to realize some substantial relief (Panwar et al., 2011).

3.3: SUSTAINABILITY AND CULTURAL HERITAGE

The sustainability is a major challenge in cultural heritage and its management. The approach needs to be so modified that it respects the involvement of the variety of stakeholders during operational as well as restoration phases, using sustainable practices. Also the restoration cannot by simply left to maintenance crew only. In the context of building engineering, often maintenance people are made to clean up after major design and construction issues. The industry thus has standardized sustainable construction practices in the form of LEED – Leadership in Energy and Environmental Design, which consists of a suite of rating systems for the design, construction and operation of high performance green buildings, homes and neighborhoods. The sustainable restoration demands for designing to minimize the maintenance (VanDerZanden and Cook, 2010).

Traditional approaches of the protecting and preserving the cultural heritage were significantly focused on limiting the impacts on the natural, social and cultural environments. The perspective was essentially limited to repair and short-term in its approach. In order to ensure the longevity of sustainable development, resource and diversity issues become increasingly predominant. The protection and preservation of environmental, economic, social and cultural resources is interconnected and can draw on common definitions of resources. The conservation of diversity in its different forms becomes a central long-term objective which must be based on a dynamic integration. Through their historic diversity, quality and continuity the building stock and the urban continuity constitute non-renewable resources. Urban culture is intrinsically sustainable and has a high stability. It is the result of the accumulated investments of generations in the urban environment. The better we understand how to administer and develop these investments, the stronger the urban environment will become (Hassler et al., 2002).

The definition of sustainable development attributed to the Brundtland Commission report survives as the least contentious (and heavily consensual) probably because due to its all-inclusiveness, there is dearth of precision and thus it is open to all sorts of subjective interpretations according to stakeholders' interests and comfort. This over-generalization (or lack of specificities) is the underlining problem which manifests the hardship of contemplating and finalizing the actions needed for achieving sustainable development. The 'three pillars' model is an advancement of sort towards simplifying the problem by nominating three dimensions: environmental, economic and social (Adams, 2006; Keiner, 2005).

In theory, the environmental pillar is the dominant concern of sustainable development and is overwhelmingly regarded as a check on human development. It mainly covers, controls and dictates the use of natural and environmental resources, and owing to the existing body of knowledge in these areas, which has resulted in well-established quantities, this aspect of development is seen as the most tractable. The continued perceived prominence of this pillar is due to its ability to addresses the needs which are at the core of human survival (Tweed and Sutherland, 2007). However all is not hunky dory when it comes to clear, obvious and intended misuse and exploitation of natural resources (Meadows et al., 1972).

In the context of cultural heritage until recently, the environmental focus has mainly been concentrated on the technical problems of maintaining the fabric of existing buildings, for example, those subject to attack from chemical pollutants in urban environments (Tweed and Sutherland, 2007), which establishes yet again the part of argument at the beginning that sustainability has remained short-sighted within operations and maintenance only. The environmental focus must not only be taken in the form of cause but also as a source of threat towards the fragility of structural and architectural integrity of cultural heritage buildings. In this regard, it is paramount to mention that the environmental changes, caused by intricate human activities, other than posing serious threats to various life forms, are also a major source of risk for the centuries old structures, which must be considered while planning and constituting the policy matters regarding sustainable cultural heritage management.

The economic pillar, without a doubt, is not only considered to be the most important prerequisite for the fulfillment of human needs and for any durable improvements to the living conditions of citizens but is also given a significance which outshines that of the other sustainability pillars. However, the global growth and progress of an entire society are not necessarily directly proportional to personal or collective economic growth. Also, the evolution of economic growth contributes into the economic inequality as well; Kuznets' hypothesis was that as a country develops, there is a natural cycle of economic inequality, as illustrated in Figure 3-5, driven by market forces which at first increases inequality, and then decreases it after a certain average income is attained (Selden and Song, 1994). Increasingly, the qualitative characteristics of development are perceived as much important as the material improvements. In other words, it is no longer reasonable to attain the economic growth in isolation from all other aspects of development.

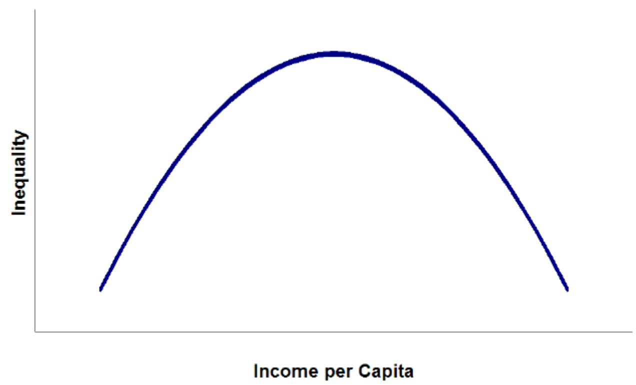

Figure 3-5: Socio-economic Kuznets curve

The role of historic buildings in promoting economic growth through urban regeneration is now acknowledged. UK seems to have taken the lead (ODPM, 2005); however other countries are also attempting to ensure economic stability from maintenance and operations of built heritage, which attracts tourists, particularly to established heritage cities, which boost the local and national economy.

The social pillar of sustainability underlines the need to improve the quality of life for all the citizens by raising base levels of material income and by increasing social equity, such that all groups have fair access to education, livelihood and resources quantitatively (Empacher and Wehling, 2002). This dimension is the most significant step towards deeming the built cultural heritage as part of sustainable development. Of particular relevance to this line of argument is the concept of inter-generational equity through which the current generation preserves cultural capital (Bourdieu, 1984) for the benefit of future generations (Adams, 2006).

Therefore, built cultural heritage has an important role to play in all three dimensions in order to ensure sustainability. However, this notion is not addressed by either of the two European procedures used to assess the impact of urban plans and projects on the environment: Strategic Environmental Assessment (SEA), or Environmental Impact Assessment (EIA). Tweed and Sutherland (2007) have investigated the potential for existing legislation based on SEA and EIA to incorporate cultural heritage in the EC-funded SUIT project. Their work is aimed at incorporating the sustainability concerns into not only the general upkeep of built heritage artifacts but also involve its notions during the important activities, such as restoration.

3.4: ROLE OF PRM IN SUSTAINABLE DEVELOPMENT

The pertinence and significance of sustainable development has already been established along with its association with the artifacts of built and architectural cultural heritage. At this point, it is imperative to investigate and understand the role PM and PRM can play towards achieving a holistic sustainable development encompassing all its pillars. This involves understanding how effective risk management, for example, is playing an important role in the construction industry and culminates into the takeaway lessons for incorporating in restoration projects to achieve similar or even better results.

To begin with, risk management contains, first of all, the concept of ‘risk’, the meaning of which is at least as debated as that of ‘sustainability’ (see for example Beck, 2000; Renn, 1992; Royal Society Study Group 1992; Rayner, 1993; Szerszynski et al., 1996); however, it seems to enjoy a key position towards achievement of sustainable development (Sage, 1998). In doing so, part of the challenge is the increasing demand for knowledge integration, especially in the cross-functional organizations (Huang and Newell, 2003) – such as the ones required to undertake a restoration project. This provides critical drive to these organizations pushing them towards complex systems with multiple underlying levels of intricacy. Architectural ecology, for example, is one more cornerstone giving raise to the overall complexity of the system. This, however, offers a strong incentive for looking at the problem from the systems engineering point of view, which is the process of realizing high-quality, reliable systems represented in projects and services which aim at satisfying the client objectives in holistic manner (Sage and Rouse, 2011; Sage, 1992). Not only this, there is an exceedingly incentivizing motivation for incorporating the concept of Life Cycle Thinking[3] in restoration projects, which seems to have been partly introduced in construction industry (Olander, 2012; Kohler and Moffatt, 2003). The construction projects also seem to have an idea of managing sustainability as well (Khalfan, 2006).

Further, there is a great deal of synergy and alignment between the sustainable development and risk management; both seem to contrast, contradict and complement each other at many fronts. In their important work, Gray and Wiedemann (1999) have tabulated an interesting comparison between the main features of Risk Management and Sustainable Development by dissecting the terms into their basic parts, as illustrated in Table 3-1.

It can be clearly see here that despite the apparent difference of approach, focus and goals between the two areas of knowledge, there is a tendency of integration in order to serve the increasingly complex and intricate scenarios. Both are future oriented in their nature; however the notion of risk management focuses more on near-term goals, which are inherently project-based in their characteristic. The focus of sustainable development, on the other hand, is more far-stretched and can be encapsulated in program- or policy-level plans. Leaving aside the contending notions, both risk management and sustainable development can also be seen as different but complementary concepts.

Hence, it can safely be deduced that PRM adds tactics- and operations-level details into the notion of sustainability; it incorporates the more short-term and easily measurable goals and objectives. Thus, this integration helps in improving the performance and delivery mechanism of sustainable development, paving a way towards the kind of development and projects which are more holistic, systematic and sustainable in their nature. The PRM framework presented in Chapter 8 takes into account the opportunities discussed here and attempts to provide a sustainable solution to managing risks in restoration projects.

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[3] Life Cycle Thinking is becoming increasingly fundamental in the development of key environmental policies around the world and is used to inform an array of decision making processes in business, technology and management. It is a different approach to becoming mindful of how everyday life has an impact on the environment – not only this, but from a sustainable development point of view, the notion can be extended to cater for economical and societal indicators. It evaluates how both consuming products and engaging in activities impacts the environment not only at one single step, but takes a holistic picture of an entire product or activity system. It seeks to identify possible improvements to goods and services in the form of lower environmental impacts and reduced use of resources across all life cycle stages.

A. Core concepts ('risk' and 'sustainability')		
Feature	*Risk (natural science concept)*	*Sustainability (strong to weak/Agenda 21 concept)*
Typical time reference	Short to medium-term future	Medium to long-term future
Main focus	Focus on loss	Focus on benefits (and system limits)
Uncertainty component	Explicitly calculated	Implicit
Type of potential loss considered	Mainly human biological/physical (and financial)	Environmental, social, economic
Level of analysis of potential loss	To individuals/groups	To systems (ecosystem/social system/economies)

B. Contexts of application ('management'/'development')		
Feature	*Risk management*	*Sustainable development*
Context or 'mission'	Management (protecting status quo)	Development (initiating or fostering change)
Decision-making approach	Risk-benefit assessment (optimization)	Precautionary principle
Message format	Quantities, especially probability-based estimates	Qualities, theories and visions as well as quantities

Table 3-1: Comparison of main features of 'Risk management' and 'Sustainable development' Gray and Wiedemann (1999)

CHAPTER 4

PROJECT RISK MANAGEMENT TRENDS IN CONSTRUCTION INDUSTRY

Due to a high level of risks and uncertainties that affect its projects, the construction industry is positioned to be an ideal environment for the diffusion and application of PRM techniques and software tools. The striking similarity between greenfield construction and brownfield restoration is at the core of this thesis; since they share so much, it will be useful to learn lessons from the construction projects and apply them in the restoration activities of built cultural heritage. Maintaining this point of departure, it is imperative to find out the diffusion of PRM in the construction industry and attempt to figure out its maturity in order to draw critical conclusions and compile takeaway lessons.

Construction projects are reported to bear considerable, and at times unforeseen and unmanaged, cost and schedule variations (Hendrickson and Au. 1989). Furthermore, the tendency to develop large-sized projects results with increased complexity, bundled with greater level of risk and uncertainty (Abdelgawad and Fayek, 2010). Also, the intricate nature of stakeholder relationships further stresses the need for affective risk management (Artto et al., 2010). Therefore, the construction industry is well-positioned to benefit from exposure to PRM formal techniques and associated software. PRM software tools help in achieving quick and correct results, but their usage in the construction industry is limited, even though with high reported success rate (Baker et al., 1999).

There are a number of mature and established software tools in the market that might apply to construction risk practice; however, it is perceived that construction professionals are still seeking other viable techniques. This is probably affected by the shortage of literature supporting the development of commercial software tools and their testing has largely been limited to research only (Öztaş and Ökmen, 2004). Despite the claim that PRM needs to be implemented in construction projects, risk management techniques are not practical and do not enhance the effectiveness of PRM as compared to current PRM software tools. In an attempt to explore the reasons and justifications for lesser diffusion of PRM techniques and related software tools in construction industry, the objective of this research was to understand how risk is managed; which methods and techniques are used; what is the level of penetration of software tools; and how the monitoring and control activities are performed in the construction sector across the world. In order to obtain sizeable and considerable information regarding such critical queries, a survey was carried out that exclusively targeted management personnel working in construction industry in various areas, such as project management, finance, legal, claims and contracts, etc.

4.1: SOFTWARE TOOLS FOR PRM

Research has mainly been concentrated on manual techniques, as evident from earlier sections. This has caused a void in the literature for software systems for PRM. A common feature of the majority of commercially distributed PRM software tools is their capability of enabling the building of complex risk models. The inputs are time and cost or other quantities along with corresponding probability distributions.

There are several quantitative risk analysis software products today that support risk modeling and risk estimating under the forms of spreadsheet adds-in or planning package adds-in. Enterprise risk management also suggests usage of technology and software tools (IMA, 2007). Caldwell and Eid (2007) have attempted to assess vendors of risk management software associated with financial processes. This assessment includes most of the vendors of commercially available tools. Also, there is a comparison of software tools for analyzing information security risks (IT Governance Ltd., 2007). Further, for a review and analysis of commercially available software, it is recommended to read Diep's (2003) work where he provides an extensive and informative market review and comparison between various PRM software tools.

It can also be argued here that recent work on assessing and comparing risk analysis and management software tools seems missing, giving rise to the need of more research and focus in this area.

4.2: RESEARCH METHODOLOGY

In order to collect data for this research, survey method was considered to be useful. Survey research is mainly used to assess and measure the thoughts, opinions, and feelings of respondents (Shaughnessy et al, 2011). It can either be specific and limited within certain geographical zone, or it can have more global, widespread goals and outreach. The penetration of this method may be witnessed in practically every field. Psychologists and sociologists make use of this method in order to analyze human behavior. Moreover, it may also be used to meet the more pragmatic needs of the media, such as, in evaluating political candidates, rating polls, public health officials, professional organizations, and advertising and marketing directors. It provides a reflection on the collective perception of a sample of respondents. A survey consists of a predetermined set of questions which is presented to a sample (Shaughnessy et al, 2011). It is of utmost importance that the sample being surveyed must be representative of the population. The significance and representativeness can be ensured using the rules of statistics. With a representative sample (one that is representative of the larger population of interest), the attitudes of the population, from which the sample was drawn, can described with a certain confidence level. Further, the attitudes of different populations hailing from different geographical areas can be compared as well changes in attitudes over the time may also be detected (Kruskal and Mosteller, 1979).

For a meaningful survey, it is paramount to select a *'good'* sample as it allows the most needed generalization and extrapolation of the findings from the sample to the entire population, which is the whole purpose of survey research (Devore, 2000).

A questionnaire is a research instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondents. Questionnaires are written surveys that are sent either through the mail or using online methods to the selected members of the population to be surveyed. Questionnaire surveys are considered to beg good response rates with rigorous follow-up procedures. They are also relatively easy to obtain from a listed population and locate respondents. Further, they help in avoiding interviewer biases and distortion, and answers are unlikely to be socially influenced. They offer easy administration and are relatively low costs, covering a wide geographical area. Thus they are more manageable for handling larger samples. However they have their share of cons, such as a questionnaire may be given to someone else to fill out or may not reach the desired respondent. It is also challenging to design a questionnaire; sometimes it is hard to interpret open-ended questions. Further, the sequence in which respondents answer is beyond control and they fail to provide any help for sequenced surveys. Finally, they are time-consuming given periodic mail-out requirements (Fairfax, 2012).

Though aware of the pros and cons, this research has made an exceptional use of questionnaire survey using online means. Although the affectivity of this method of data collection is not considered at par (Guldenmund, 2007; Edwards et al, 2002), there always are measures which may be taken to improve the response rate and relevance. Further, considering the shortage of time and other resource constraints, questionnaire survey was considered to be the most viable tool.

4.3: PREPARATION OF THE QUESTIONNAIRE SURVEY

Considering the threats and opportunities, limitations and advantages, and challenges and gains, a good deal of time and effort was invested in preparing a questionnaire survey that not only meets these challenges but is also capable of gathering the required information with foreseen level of precision. The common pitfalls, which were already known, were avoided as much as possible using the methodologies of improving the questionnaire surveys (Bryman, 2012; Bailey, 2008; Patton, 1990). Special guidance was drawn from the pivotal work of Kitchenham and Pfleeger (2002) where explicit guidelines and principles of survey research are presented.

4.3.1: Structured questionnaire survey method

The general methodology of this study relies largely on the questionnaire surveys as mentioned before. These surveys were collected from the construction management professionals. The data was collected with the help of online survey tool. A thorough literature review was initially conducted to identify the software tools and techniques that are used in the industry for risk management. Also in order to find out that at which steps of the risk management process which risk techniques and tools can be used, PMBOK (PMI, 2008a) was heavily relied upon. Also the risk management process of PMBOK was utilized in order to inquire the phases in the survey. The given below Figure 4-1 shows the risk management process.

Figure 4-1: Project risk management process

Each of these processes represented in the Figure 4-1 has some associated tools and techniques which are the main objective of this research. Thus, in this sense, the main goal is to identify which tools and techniques are currently used in the global construction industry and what are the correlations.

The basic theoretical framework identifies the tools and techniques for each of these processes. The employed framework by PMBOK offers a number of tools and techniques for various risk management phases. These tools and techniques were presented in the questionnaire survey to inquire which of these are utilized by the respondents. In case of other techniques, the necessary options were provided to allow the respondents to mention the tools and techniques they use. Figure 4-2 shows the tools and techniques offered by PMBOK. It is important to remark that this research attempted to focus its attention at the entire lifecycle of risk management process, affiliated tools and techniques, as well as the software solutions. However risk response planning and risk management planning were left aside because these processes depend on the characteristic of the risk, and features and goals of the company.

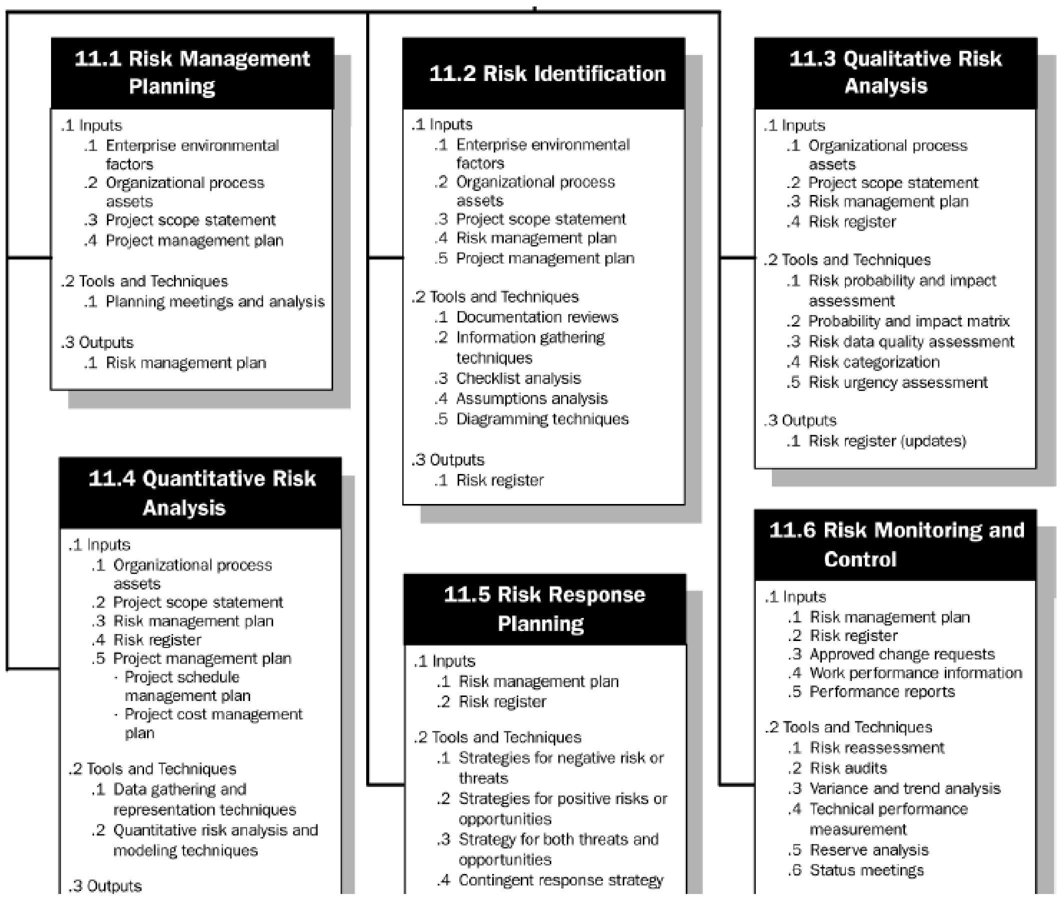

Figure 4-2: Tools and techniques for risk process according to PMBOK

For the online survey, after creating the questionnaire, placing it online, and recruiting subjects, a researcher’s primary data collection efforts are complete. Hundreds of respondents can fill out the survey within a matter of days, and all of these responses can be automatically inserted into a spreadsheet using automatic online survey tools. In this case, “Google ™ Docs” tool was used, which gives the flexibility of not only collecting data over the Internet, but it is also capable of performing validation based on researcher requirements. That way, data from web-based questionnaires can automatically be validated; for example, if a data value is entered in an incorrect format, or outside a defined range, the web-based program can return an error message requesting the respondent to enter the data correctly and resubmit the questionnaire. If such validation capabilities are used, the researcher does not need to worry about issues of missing or out-of-range responses, and can proceed directly to preliminary analysis of the data.

It should be noted, however, that automatic data validation cannot guarantee the veracity of respondents' answers.

The next big step was to reach the practitioners and professionals of construction management. Since there may exist an unlimited and hence unknown population of professionals dealing with risk management in the construction industry globally, selection of respondents proved to be an uphill task. But thanks to the online professional communities like "LinkedIn®", the selection of respondents became easy. It is worth mentioning here that LinkedIn operates the world's largest professional network on the Internet with more than 100 million members in over 200 countries and territories. This did not only provide us with the opportunity to contact construction risk management professionals in any one country or territory, but across the world. Furthermore, there are specialized interest groups in this online community of professionals and keeping in view the requirements of this research, following groups were selected and their members contacted for participating in the survey:

- Contract Risk Management Group-Construction Industry
- Construction Risk Management

Also this research attempted to investigate the types of data required to be fed into the software tools and establishing if there is any pre-processing needed before being used in the simulation tools. Software tools are evaluated based on the type of input required by them, as well as the output obtained.

Taking into account the research of Diep (2003), in which a comparison among software tools under the "Cost criteria" in the market was carried out, some sample tools that were evaluated in TRW[4], NASDAQ[5], and PricewaterhouseCoopers[6] were provided in the research. In this sense, one of the objectives was to try to investigate if they are currently used in the construction industry and also discover new software tools that are being used.

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[4] American corporation involved in a variety of businesses, mainly aerospace, automotive, and credit reporting.

[5] "**N**ational **A**ssociation of **S**ecurities **D**ealers **A**utomated **Q**uotations", American stock exchange.

[6] It is the world's second-largest professional services firm (after Deloitte) and one of the "Big Four" accountancy firms.

Product	Usage by PIER
Crystal Ball	Evaluate
Criterium Decision Plus	Evaluate
Q-Sim	Evaluate
PaR	Evaluate
@Risk, PrecisionTree	Evaluate
FlowCharter 7	Identify-Evaluate
CRS	Identify-Evaluate-Respond
Risk+	Plan
Active Risk Manager	Plan-Identify-Evaluate-Respond
RDD-100	Plan-Identify-Respond
Risk Manager	Plan-Identify-Respond
RiskTrak	Plan-Identify-Respond
LDRPS, BIA Pro	Plan-Identify-Respond
DOOR	

Figure 4-3: COTS tools available by PIER model

The Figure 4-3 presents a classification of the COTS[7] tools according to the PIER model. PIER represents Planning – Identifying – Evaluating – and Responding of software tools. Another level of elimination was applied in order to use a sample from the published work by further categorizing based on an extensive internet research. The need was felt in order to make the questionnaire concise, easy and convenient: a research on the internet was performed in which some software tools were ruled out those which did not have an important presence. The resulting software tools are the following:

- Crystal Ball
- @Risk
- Precision Tree
- Criterium Decision Plus
- Risk+
- Active Risk Manager
- RiskTrak

Software tools were subsequently evaluated based on their quality according to the Likert scale of 1-5 used in the questionnaire, for parameter such as:

- Ability to customize
- Usability/user friendliness
- Extended functionality/variety of functions

[7] Short for ***c**ommercial **o**ff-**t**he-**s**helf*, an adjective that describes software products which are ready-made and available for sale to the general public. They are designed to be implemented easily into existing systems without the need for customization.

- Compatibility with other programs
- Technical support
- Cost (self-addendum)

In this way, the respondents were required to respond in order of importance from 1 (least important) to 5 (most important) of attributes of the risk software, and also functions that they considered important, such as:

- Importability/exportability into other PM software systems
- Reporting
- Probability simulation
- Risk/treatment database
- Risk/treatment management

4.3.2: Selection of the sample size

The survey questionnaire was focused on the professionals pertaining to the management area of the construction industry, but not limited. The job titles varied, such as:

- Planning Engineer
- Project Manager
- Resident Engineer
- Commercial Manager
- Construction Manager
- Contract Manager
- Consult Manager
- Risk Manager
- Risk Consultant Manager
- Program Manager
- Quality Manager
- Planning Manager
- Technical Manager

A critical aspect for the research is the selection of the sample size; regarding this issue Bartlett et al (2001), in their seminal work sample size selection, argue that *"inappropriate, inadequate, or excessive sample sizes continue to influence the quality and accuracy of research"*.

Thus, it can be noted that selecting sample size, which not only represents the unaccounted for population, but is also practically viable for two entirely different surveys was extremely challenging. Although equally challenging, the norms of statistic could be played with for the global survey sample, as the convenience offered by online tool could discount the effort. However same was not true of the Pakistani sample. Thus two different strategies were applied for selecting samples for the survey. Nevertheless, the statistical justification was never violated; hence both samples are statistically correct and representative of their respective populations.

The sample size for global survey is based on the procedures for categorical variables using Cochran (1977) formulae.

$$n_0 = \frac{(t)^2 * (p)(q)}{(d)^2}$$

$$no = \frac{(1.96)^2 * (0.5) * (0.5)}{(0.06)^2} = 267$$

Where:

t= value for selected alpha level[8] of 0.025 in each tail=1.96

(p)(q) = estimate of variance[9] = 0.25

d=acceptable margin of error for proportion being estimated[10] =0.06

Cochran (1977) also suggests comparing the previous sample size with the 5% of the population but since this research aims to describe the behavior of the professional across the globe, estimation was difficult to make. However the equation is the following

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[8] The alpha level of 0.05 indicates the level of risk this research is willing to take that true margin of error may exceed the acceptable margin of error.

[9] Maximum possible proportion (0.5)*1-maximum possible proportion (0.5) produces the maximum possible sample size.

[10] Level of error which is tolerable for this research.

$$n_1 = \frac{n_0}{(1 + n_0 / \text{Population})}$$

From this formula, it is easy to predict that there is no need for correction for the sample size since the population is assumed higher than 267/0.05 = 5340 professionals. As well as, it is important to mention that only professionals who are members of the groups of Risk Management (Construction) in the network LinkedIn were the focus of global sample. This was decided following the assumption that these professional were more introduced in the ICT, which is fundamental when advanced techniques for risk management such as Monte Carlo Simulation are under question.

This process results in a minimum returned sample size of 267 professionals. Since the web-survey method response rate is below 100%, according to Salkind (1997), it is always convenient to oversample: *"if you are mailing out surveys or questionnaires, count on increasing your sample size by 40%-50% to account for lost mail and uncooperative subjects"*.

Assuming a response rate of 65%, a minimum drawn sample size of 411 should be used. These calculations were based on the following:

Anticipated return rate=65%

n2=sample size adjusted for response rate.

Minimum sample size corrected = 267

Therefore, n2= 267/0.65=411

The following table (in Figure 4-4) was developed by Bartlett et al (2001) in order to calculate the sample size for continuous and categorical data with an error of 0.03 and 0.05 respectively.

	Sample size					
	Continuous data (margin of error=.03)			Categorical data (margin of error=.05)		
Population size	alpha=.10 t=1.65	alpha=.05 t=1.96	alpha=.01 t=2.58	p=.50 t=1.65	p=.50 t=1.96	p=.50 t=2.58
100	46	55	68	74	80	87
200	59	75	102	116	132	154
300	65	85	123	143	169	207
400	69	92	137	162	196	250
500	72	96	147	176	218	286
600	73	100	155	187	235	316
700	75	102	161	196	249	341
800	76	104	166	203	260	363
900	76	105	170	209	270	382
1,000	77	106	173	213	278	399
1,500	79	110	183	230	306	461
2,000	83	112	189	239	323	499
4,000	83	119	198	254	351	570
6,000	83	119	209	259	362	598
8,000	83	119	209	262	367	613
10,000	83	119	209	264	370	623

Figure 4-4: Table for determining minimum returned sample size

The most important fact in the above table is observing that the trend of the sample size remains constant without importance of the population for the continuous and categorical data which supports this research given the uncertainty in total number of the population.

It is important to highlight that the final sample size for the analysis was kept as 267 to avoid an increase in the probability of Type I error[11].

In order to avoid using Student-T distribution and preferring the normal distribution, a minimum sample size of 30 was required. If n>30 in surveys, the normal distribution may be accounted for. Further:

- the populations usually have a central tendency, that is, a propensity for values to be near the mathematical average for the population as a whole;
- the departures from average are symmetric, that is, there is the same chance for an individual to have a value greater than average as for it to have a value less than average;
- the probability of a given departure from average decreases rapidly with its size - small departures are very likely, larger ones are less likely, very large ones are extremely unlikely.

[11] Alpha error: finding a difference that does not actually exist in the population

If any one or more of these is not true, the distribution will not be normal. However, for extremely large samples, most real world data approximately meet these conditions anyway, even if they do not adjust for sample sizes of 30. In reality, small samples from normally distributed populations are more likely to fit the Student-T distribution, which is like normal but more sharply pointed. $n>30$ is not inherent in the Central Limit Theorem, it is a convention that makes the proof calculations easier. It facilitates the conversion to polar coordinates and back that is used to prove that the Gaussian formula is a valid probability distribution. Thus a sample of 66 (which is almost 2n for a normal distribution) easily fulfills the requirement for being a candidate sample for normal distribution.

4.3.3: Sections of questionnaire

The method applied for questionnaire survey consisted of small briefing by the survey questionnaire on the Section 1, in which the respondents were introduced with the objectives and scopes of the research. And then, Section 2, in which personal data was collected. Afterward the data about the risk management process awareness was collected.

The questionnaire was designed in order to require suitable time to be completed. The overall response rate was encouraged, despite of all the busy and hefty schedules of respondents.

In the first part of the questionnaire, data was gathered regarding the background information of the respondents. Questions asked were of the nature, such as: role in construction industry; type/field of business; name of company; no. of projects per year; job title; total experience, age and years in current position. This section of survey was presented in last for the global respondents. Also, it is important to mention that these parameters were set as optional; respondents could voluntarily answer for these questions, in order to increase the response rate, and to avoid loss of information collected in the survey because of the private information.

In the next section of survey, an assessment of the current tools and techniques used by construction management professionals through the different steps of the risk management process was carried out.

The next part of the survey attempted at understanding the share of the respondents who use risk software tools in terms of what input do they need for assessing risk in the software tools and also to what level they need to pre-process the input. Moreover, it was asked as to what are the outputs they get from the risk software tool and to what point this outputs need to be worked upon further.

For the group of professional who do not use risk software tools, it was asked to give reason(s) about not using the software. In this way, the risk software developers could track the needs of the risk management professionals.

4.3.4: How to fill out/answer the survey

Background information was not compulsory, so those who did not provide it were also considered for drawing some critical conclusions

It is important to mention that the respondents could reply all the answers, multi-check/multi-select, and in consequence the total percentages were over 100% and the total record count varied for each question. It was done in this way in order to allow professionals who use more than one technique to draw conclusions in any of the risk management process by responding according to the real situation.

The survey was focused to analyze two segments of risk management, if a respondent answers 'Yes' (or 'No') to the usage of software question, then they were directed to the next question. 1) the ones who use risk software tools to quantify risk, and 2) the ones who do not use risk software. In this way Google ™ Docs allowed the respondents to be taken on separate pages in which the follow-up questions were made to the specific segment. However the same was done manually for local survey respondents.

Software tools were subsequently evaluated based on their quality according to the Likert scale of 1-5 used in the questionnaire, for parameter such as:

- Ability to customize
- Usability/user friendliness
- Extended functionality/variety of functions
- Compatibility with other programs
- Technical support
- Cost (self-addendum)

In this way, the respondents were required to respond in order of importance from 1 (least important) to 5 (most important) of attributes of the risk software, and also functions that they considered important, such as:

- Importability/exportability into other PM software systems
- Reporting
- Probability simulation
- Risk/treatment database
- Risk/treatment management

4.4: SURVEY RESULTS

This section highlights the findings of research; it demonstrates the analysis performed on collected data and the obtained results. The survey has been responded by a total of 271 respondents, from 56 countries which were grouped in regions: America, Europe, and Australia-Asia-Africa. The higher portion of the sample corresponds to the segments of Australia-Asia-Africa with 39% respondents. 33% participants from America and 24% from Europe also participated. In terms of countries, the highest number (66) of respondents was from USA.

4.4.1: General characteristics of the respondents

Job title

The most recurring job title in the global dataset was "Project Manager" (PM or Senior PM), followed by "Director" and "Risk Manager". Thus it can be safely deduced that the survey actually reached to the focused participants and therefore the quality of data can be ensured.

Location

The survey garnered response from a total of 271 practitioners globally. The respondents were clustered into America (North and South America), Europe and Australia-Asia-Africa groups. The largest portion of survey respondents belonged to the Australia-Asia-Africa cluster (39%); evidently this cluster covers a large portion and thus the likelihood of its largest size is obvious. Second in the row was cluster of respondents from America (33%), followed by Europe (24%), as shown in Figure 4-5. Please note that personal data was optional for global survey and thus 4% of respondents did not disclose their locations.

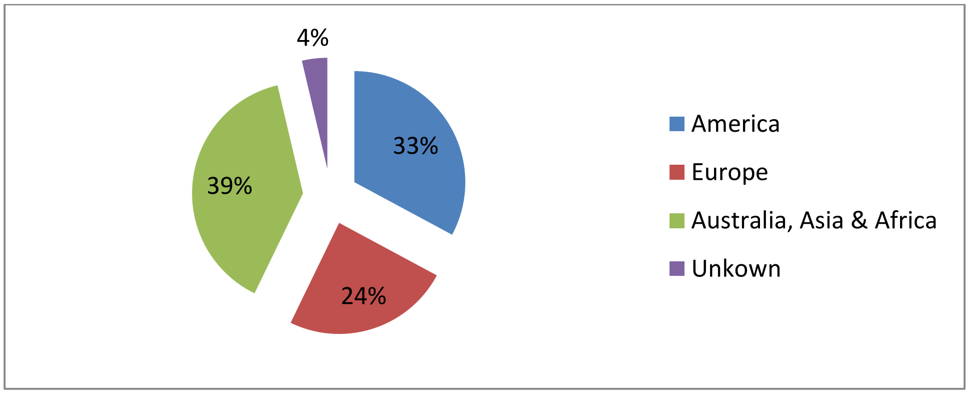

Figure 4-5: Respondents of global survey by location

Speaking of respondents from individual countries, the largest participation was from USA with a total of 66 respondents, followed by UK with 28 and India with 15 participants.

Age and years in current position

Though age was not a required filed, being part of the personal information, still a total of 254 respondents provided it, giving a 95% response rate. The reported age of participants averages 42.3 years with a standard deviation of almost 11 years. Thus it can be observed here that practitioners in global construction industry, on average, are into their mature span of life, with quite high variance, which suggests there is a representative mix of participants. Analyzing the age and location correlation further, it can be observed that respondents belonging to America cluster have the eldest ages on average, followed by Europe. The Australia-Asia-Africa cluster, thus, represents the youngest of global respondents on average, as illustrated in Figure 4-6.

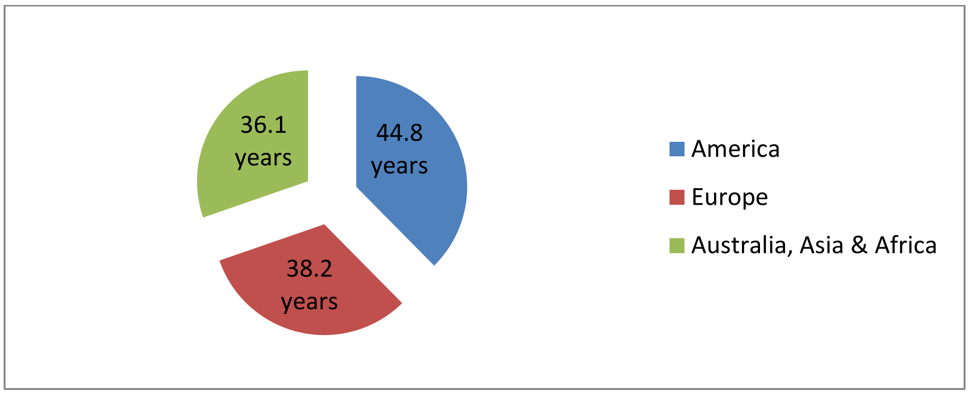

Figure 4-6: Respondents of global survey by age and location

Further, the global sample reported a total of 7 years in current position on average, with a standard deviation of 7.7 years. It can be observed here that the duration spent in current position in not normally distributed over the population (with a few changes, it can be an exponential distribution). However, it also hints that employee turnover is quite high in global construction industry.

4.4.2: Risk Management Process

Survey results show that PMI standard tools and techniques are employed by respondents to a large extent, along with some custom/proprietary tools. As mentioned earlier, the total percentage exceeds 100% to find out if practitioners are in the habit of using multiple tools and techniques.

Risk Identification Techniques

The results show that 72% of respondents identify risks through “Documentation review”, 64% through “Brainstorming” and 48% through “Checklist Analysis”, as shown in Figure 4-7. The established trend of risk taxonomies in construction industry can be attributed to high usage of documentation review and checklist analysis techniques. Also, the human interaction (brainstorming) is affective in identifying risks. On the other hand, Influence Diagrams, Delphi Technique and Ishikawa Diagram, probably based on their complexity, scored as the least (6%) used risk identification techniques. It can be argued here that construction industry professionals look for easier and affective techniques.

Apart from standard techniques, various new techniques were mentioned by respondents, such as “HAZOPS”, “FMECA”, “HLRA’s”, “Client risk”, “Experience”, “Physical inspections”, “Risk surveys”, “Dynamic risk assessments”, “On-site inspection”, “Analogous data analysis” and “Cost control tracking system”.

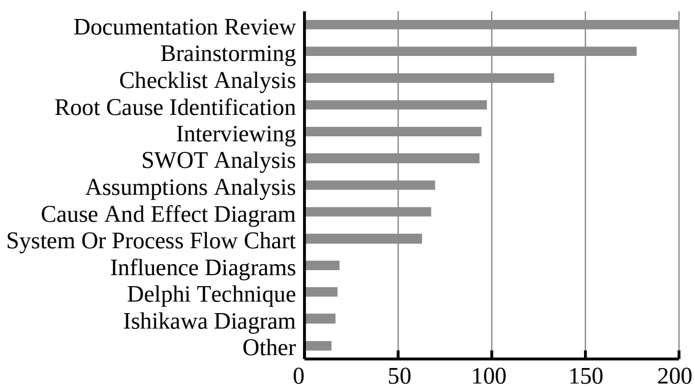

Figure 4-7: Risk identification tools and techniques

Qualitative Risk Analysis Techniques

It is found that 66% of respondents use “Risk Probability and Impact Assessment” for qualitative risk analysis, 49% use “Risk categorization” and 35% use “Probability and Impact Matrix”, as shown in Figure 4-8. The rationale of this phenomenon is probably based on the fact that since very beginning, the risks are associated with their probabilities of occurrence and resulting impacts, therefore, it is more natural and fluid that practitioners assess risk probabilities and impacts in the early stages.

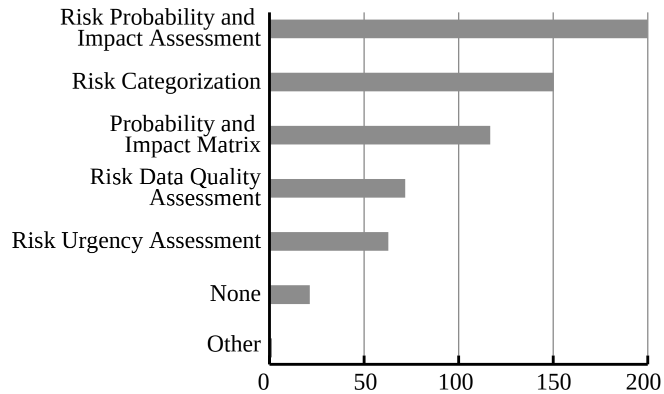

Figure 4-8: Qualitative risk analysis techniques

Quantitative Risk Analysis Techniques

Survey results suggest that 64% of respondents use "Expert Judgment" and 44% use "Interviewing" for quantitative risk analysis. Techniques more quantitative in nature, such as Expected Monetary Value, Modeling and Simulations, Sensitivity Analysis, Probability Distributions etc., are found to be diffused less (on average, these are used by 30% respondents).

It can be argued here that more complex quantitative techniques are not highly utilized and therefore convenient techniques (such as expert judgment and interviewing) find their way in highly utilized techniques.

Also, respondents suggest "Brainstorming" as a technique for Quantitative Analysis. Also, 2% respondents do not use any quantitative risk analysis techniques, as shown in Figure 4-9.

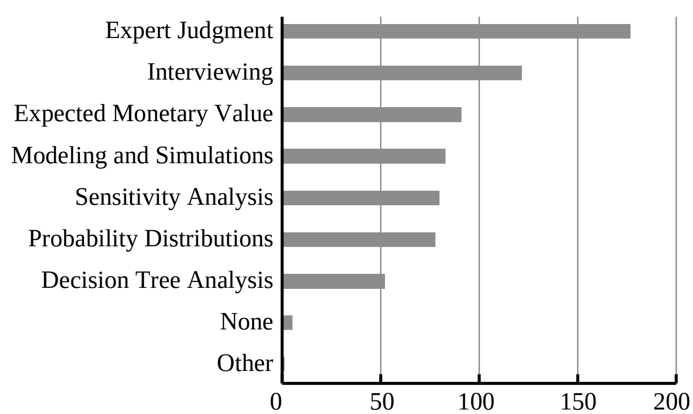

Figure 4-9: Quantitative risk analysis techniques

Risk Monitoring and Control Techniques

Results suggest that 76% of respondents use “Status meeting” and 51% use “Project Risk Response Audits” techniques to monitor and control the risk, as shown in Figure 4-10. The affectivity of direct human interaction is established once again here as the most used monitoring and control technique is to conduct status meeting.

Some new techniques are also reported by respondents, such as “Tracking by risk department”, “Other case studies”, “Decision analysis based on quantitative risk analysis outputs”, “Incident investigation”, “Safety & loss control review” and “Periodic risk register review”.

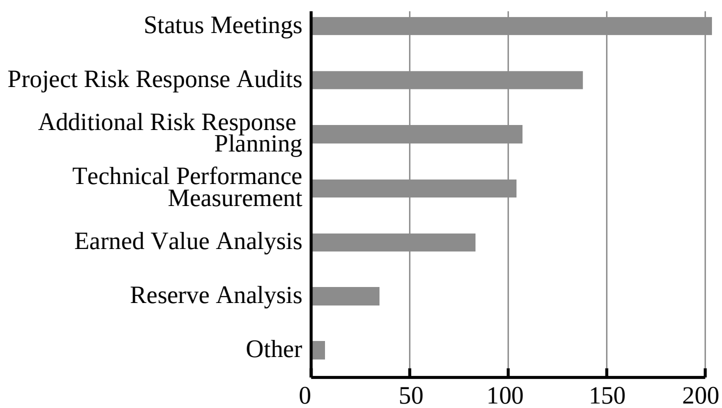

Figure 4-10: Risk monitoring and control techniques

4.4.3: PRM Software Tools

Contrary to our perception, the survey results show that only 21% of the participants use software tools for PRM, the remaining majority of 79% participants do not use these tools due to reported reasons. The region-wide distribution of those 21% (57 out of 271) respondents shows that the UK leads the list with 26.3% of users, followed by US with 15.7% users.

The tool @Risk can be considered as industry-leader amongst the respondents, based on its 42% (24 users) share, followed by Risk+ with 32% (18 users) share, as shown in Figure 4-11. A number of software tools were reported by respondents in “Other” category, such as “ViewPoint”, “Primavera Risk Analysis” (formerly Pertmaster), “Predict QRA Analysis”, “PHA Pro”, “ERA Methodware”, “RiskAid”, “RIS3” and proprietary tools developed in-house.

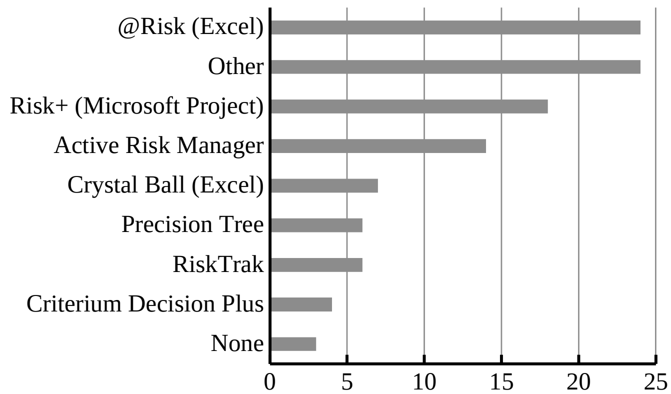

Figure 4-11: Software tools used by respondents

For input, 81% users of these tools feed in "Risk register" as input, followed by "Project cost management plan" (60%), "Risk database" (58%) and "Project schedule management plan" (53%), as illustrated in Figure 4-12. It is also remarkable to observe that these tools take variety of input details (mostly due to their focused usage) and the respondents must really have to know and prepare in advance for being able to successfully use them.

Figure 4-12: Input to software tools

Survey results also report that the data input needs to be pre-processed to a *'medium'* level before being fed into the software tool, representing 53% of the total users, followed by *'high'* level of pre-processing, representing 26.31% respondents. This, in turn, shifts some significant amount of work for manual performance, diminishing the productivity of these tools.

A considerable majority of survey respondents (65%) report "Prioritized list of quantified risks" and "Probability of achieving cost and time objectives", followed by "Probabilistic analysis of the project" (44%) as the sort of output received from the software tools, as shown in Figure 4-13. Here as well, it is important to underline that these tools have no uniformity of output details, and based on the type of input and the processing algorithm, the type of results vary.

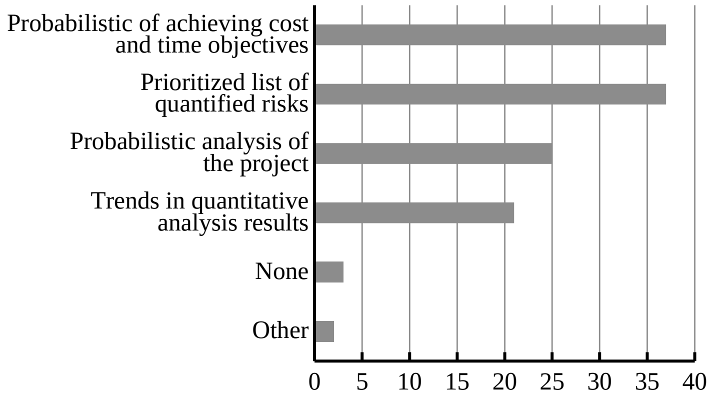

Figure 4-13: Output from software tools

Also, the output received from software tools is not readily understandable and presentable, but needs to be further worked upon. A majority of respondents (68%) report such a post-processing of output is needed, whereas 32% report no post-processing. Yet again, the productivity of these tools is challenged by the fact that the semi-processed results are further post-processed by manual performance and this may surely affect the overall results.

Apart from the minority of software users amongst the respondents, those who do not use these tools report three main reasons; "cost of purchasing, maintaining and usage of software tools" (39%), "in-sufficient tailoring for business" (35%), and "lack of product knowledge" (29%), among others for not using software, as shown in Figure 4-14. Apparently the market logic for investing in these tools is not sufficient; i.e. the cost savings realized from better risk management does not warrant the investment. Therefore, it motivates the software vendors to take into account the needs and limitations of construction industry and supply them with tools which are easy to use and operate, and are cost-effective as well.

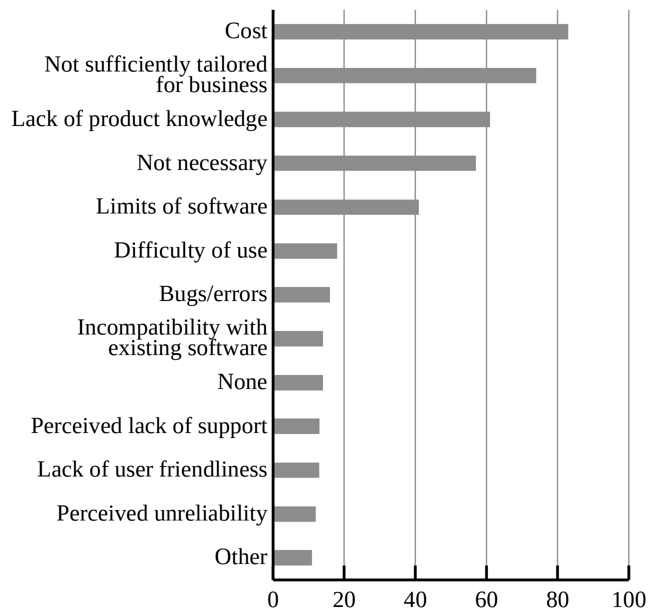

Figure 4-14: Causes for not using software tools

4.5: ASSESSMENT OF PRM SOFTWARE TOOLS

4.5.1: Attributes of Software Tools/ Add-Ins

Respondents were also asked to provide the quantitative scoring for various attributes of software tools/add-ins.

Function	Mean	St. D.
Risk treatment management	4.2	0.7
Probability simulation	4.1	1.0
Reporting	4.0	0.7
Risk/treatment database	4.0	0.8
Importability / exportability to PM software	4.0	1.1
Risk treatment management	4.2	0.7

Table 4-2: Importance of attributes of software tools/add-ins

Table 4-2 lists these attributes along with the average scores and the standard deviations. “Usability/user friendliness”, as evident from previous results, is marked as the most important attribute by the respondents, followed by the “Ability to customize” with a mean of 3.9. But also, the “Technical support” and “Cost” have been given their fair share of importance. So, it is safe to state that PRM software in construction industry is not only hurdled by their cost but also due to lack of their knowledge and technical support amongst the practitioners.

4.5.2: Functions of Software Tools/Add-Ins

The most important software features are found as “Risk treatment management”, with a mean value of 4.2 (out of 5) followed by “Probability simulation”, with a mean of 4.1, as shown in Table 4-3. It is also identified that even though the main objective of software tools is to calculate the probability of an event to occur, the users do give importance to practical knowledge for dealing with risks.

Attribute	**Mean**	**St. D.**
Usability/user friendliness	4.4	0.8
Ability to customize	3.9	1.1
Extended functionality /variety of functions	3.8	0.9
Technical support	3.8	1.1
Cost	3.8	1.1
compatibility with other programs	3.7	1.2

Table 4-3: Importance of functions of software tools/add-ins

4.6: TRENDS OF USAGE BETWEEN GLOBAL AND PAKISTANI CONSTRUCTION INDUSTRIES

In the following subsections, the trends of usage between the global and Pakistani construction industries are analyzed. Some extremely interesting findings are reported and conclusions are drawn. The associations with the previous results are also made wherever necessary and possible.

4.6.1: Risk management process

Risk identification techniques

The vast diffusion of various risk identification techniques in global and Pakistani construction industries has already been established. With stats somewhat closer, it can be safely commented that the trend of usage of risk identification between the two construction industries is slightly comparable. With highest rank to the documentation review, the popularity of personal contact based techniques is unquestionably high in both the construction industries.

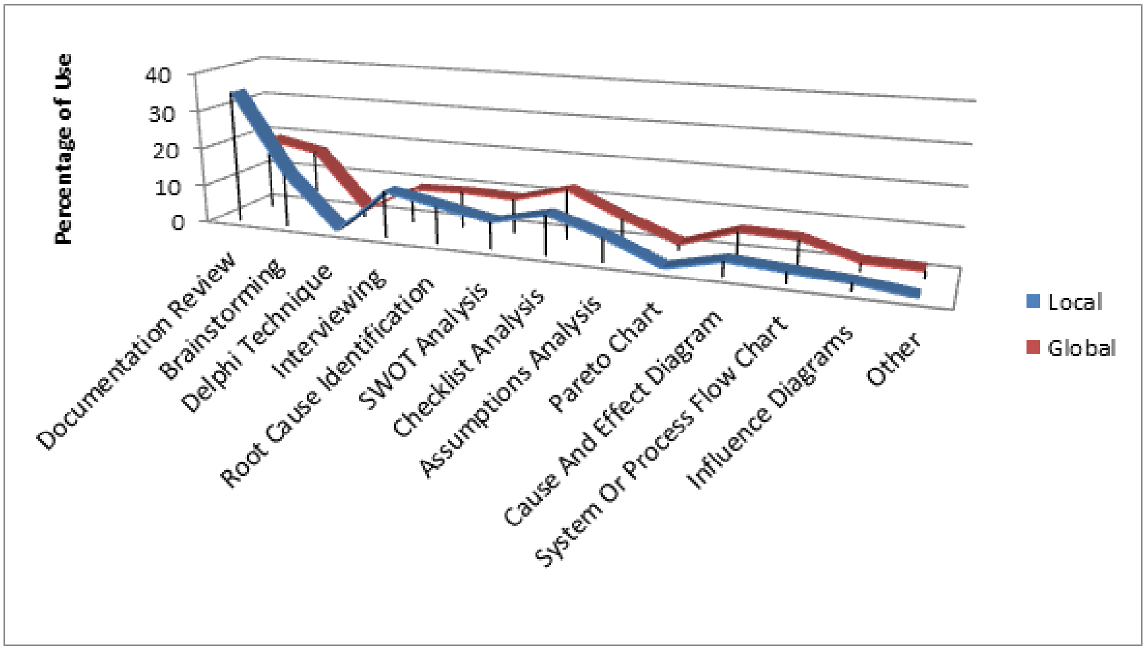

Figure 4-15: Trends of usage for risk identification techniques

Although interviewing seems to be seriously relied upon in global construction industry, same is not so true in the Pakistani context. Part of the reason may be attributed to the fact that the lack of standard practices has hampered the accumulation of risk management knowledge and thus there is a severe scarcity, if not absolute absence, of the knowledge gatekeepers[12] in true meaning of the term.

[12] Knowledge gatekeepers create a shared sociocultural context that enables the condivision (logical division or classification while coexisting with other crossing entities) of "tacit" meanings, knowledge codification, and transmission. According to the pioneer of the concept of the "knowledge gatekeeper" (Allen, 1977, p. 145), a "gatekeeper" is a key person (or a group of people) who makes possible knowledge transfer by informal communication by taking an mediator role. Gatekeepers vary from their colleagues in their orientation toward

The striking similarity between the trends of usage in the two construction industries, as illustrated in Figure 4-15, also hints at the shared indifference and disregard for more inherently complex techniques. Though those techniques offer more structured and sophisticated outcomes, the sheer complexity of usage reduces their popularity. On the whole, it can be figured out that the trend of risk identification techniques is noticeably similar between the global and Pakistani construction industries.

Qualitative risk analysis techniques

Though the role of qualitative risk analysis has already been discussed, the observations made before are further strengthened by looking at the trend of associated techniques in the two construction industries. The striking similarity between most of the techniques refers to the fact that both, global and Pakistani, construction industries take qualitative risk analysis quite informally. However, the risk and probability impact assessment and risk categorization are the two techniques which enjoy some sort of considerable diffusion, as illustrated in Figure 4-16.

Contrary to established beliefs, probability and impact matrix, being the academically preferred technique, does not find such a remarkable position in the global construction industry. However, it achieves considerably better acceptance in Pakistani construction industry.

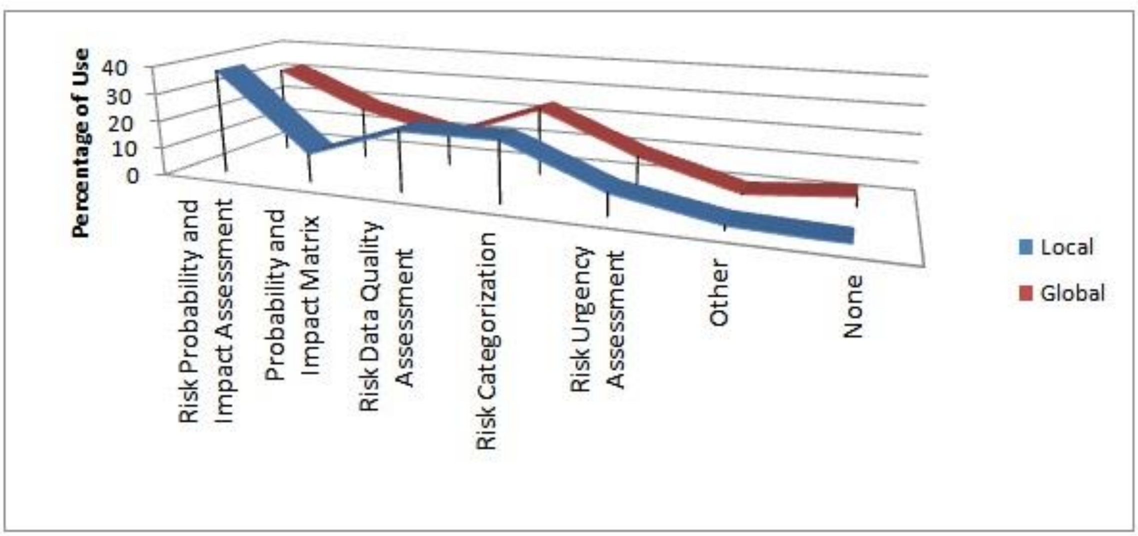

Figure 4-16: Trends of usage for qualitative risk analysis techniques

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outside knowledge sources. On average, gatekeepers read, advise local communities, search online, and present and publish papers more than researchers, scientists, academics, and local leadership do.

Quantitative risk analysis techniques

The trends of usage of quantitative risk analysis techniques are extremely interesting and astonishing: the divergence and dissimilarity between some major techniques, as shown in Figure 4-17, may only refer to varying attitudes and levels of knowledge between the practitioners of Pakistani and global construction industries. As commented before about the lack of *"knowledge gatekeepers"*, the observation is further strengthened by observing the stark difference of diffusion of interviewing and expert judgment techniques. The expert judgment technique is mostly used in global construction industry due to the established practices: availability of knowledge gatekeepers and experts facilitates the risk analysis process. However, same is not true in the Pakistani construction industry. Further, the probability distributions have a better diffusion in the Pakistani construction industry. The part of justification for higher reliance upon probability distributions may be credited to the lack of diffused expert knowledge of risk management (*tacit knowledge*[13]), which drives and motivates the practitioners to rely upon more textbook-based methods.

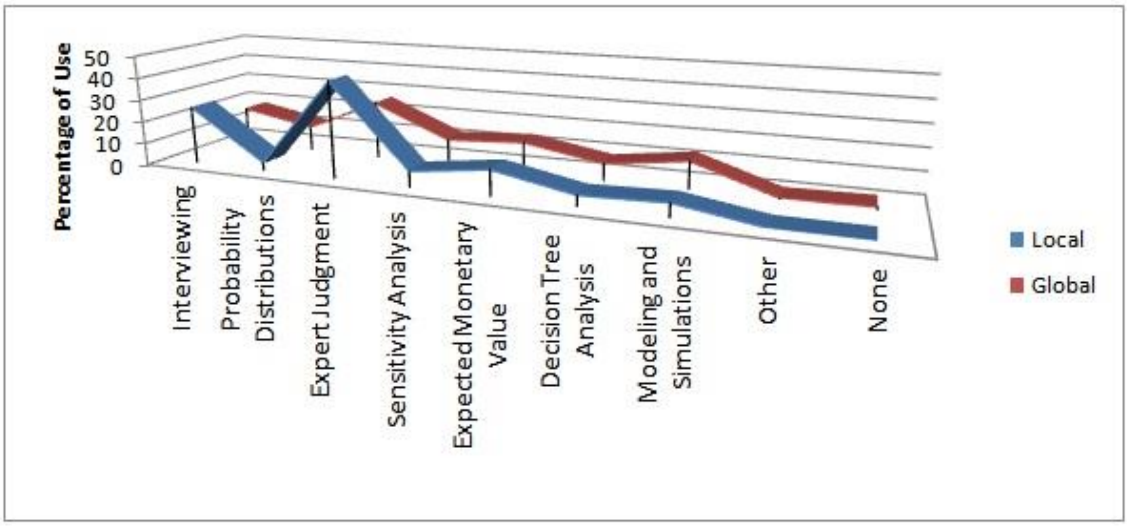

Figure 4-17: Trends of usage for quantitative risk analysis techniques

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[13] Tacit knowledge refers to unspoken, unwritten, and hidden vast storehouse of knowledge apprehended by practically every human being, based on his or her experiences, emotions, intuition, insights, observations and internalized information. Tacit knowledge is integral to the entirety of a person's consciousness, is attained largely through association with other people, and requires joint or shared activities to be imparted from on to another. Like the submerged part of an iceberg it constitutes the volume of what one knows, and forms the underlying framework that makes explicit knowledge possible. Tacit knowledge is contrasted with specific or propositional knowledge. Very loosely, tacit knowledge collects all those things that we know how to do but perhaps do not know how to explain (at least symbolically).

Monitoring and control techniques

The trend of dissimilarity and variation continues between the global and Pakistani construction industries in the segment of monitoring and control techniques. Though status meetings shares a common level of diffusion amongst the two construction industries, more structured techniques such as response audits and earned value analysis enjoy lower levels of diffusion in Pakistani construction industry compared to its global counterpart. Further observing the trends present in Figure 4-18, it may also be spotted that reserve analysis, being, though tedious, an effective way of detecting variations between reported and available reserves, has more diffusion in Pakistani construction industry compared to the global one. It may be commented here that with small to medium sized projects, the viability of such technique is affordable, however with large projects (which are quite expected for the global construction industry), such a technique does not necessarily warrant the required level of precision.

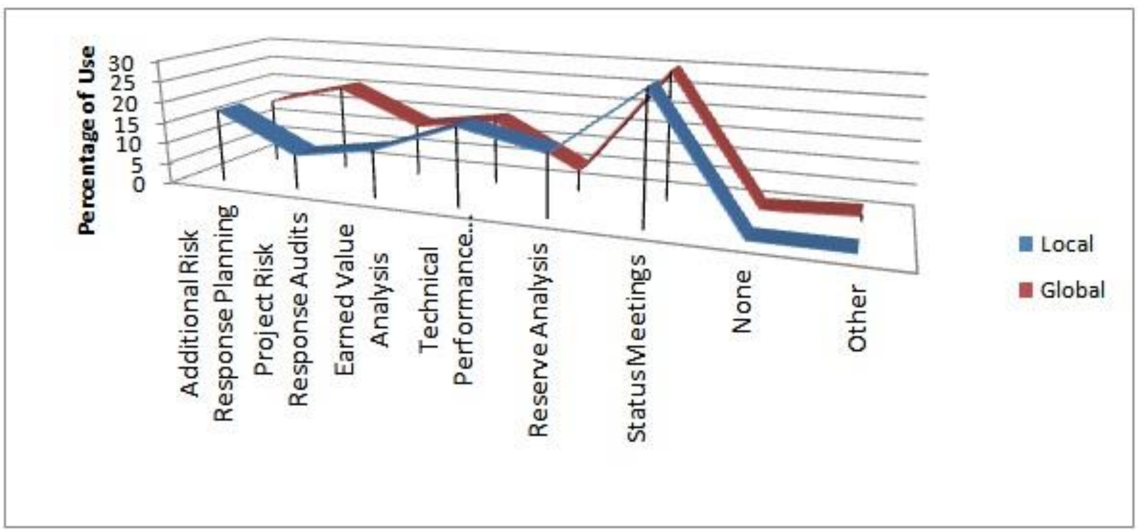

Figure 4-18: Trends of usage for monitoring and control techniques

4.6.2: Risk management software

Usage of software

The striking similarity between the penetration of software in Pakistani and global construction industries is interesting and motivating: although the level of penetration from a global perspective is not so impressing, the corresponding penetration in Pakistani construction industry is quite exciting. This puts forward the rationale that the two construction industries share some sort of hidden interaction; though demanding to defend, the association between the global and Pakistani construction industries seems partially benefiting the latter.

As shown in Figure 4-19, equal percentage of participants from both construction industries have informed of using the software tools for risk management. Though the sample of software users in Pakistani construction industry is too small for a normal distribution, the visual comparison confirms the noticeable and obvious similarity between the two construction industries.

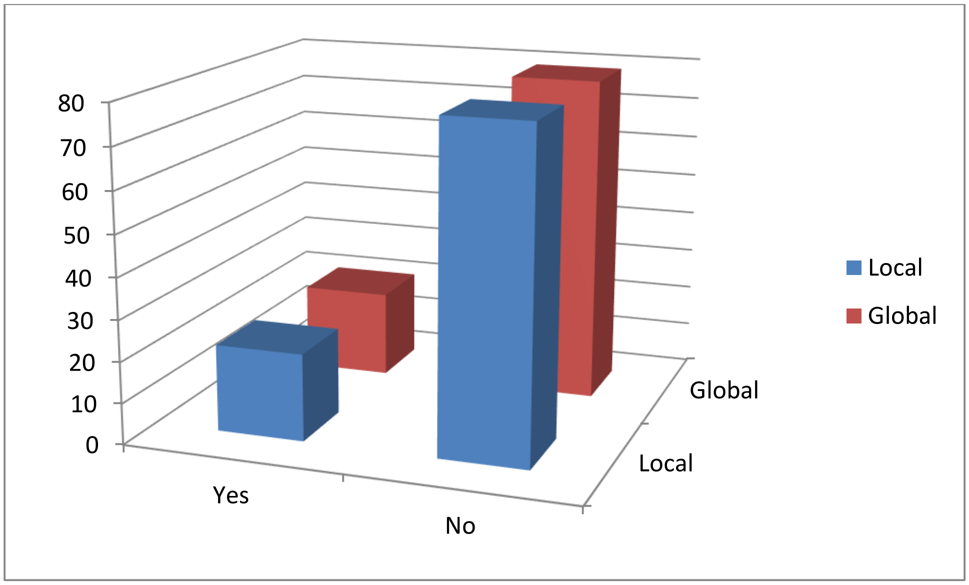

Figure 4-19: Trends of usage for risk management software

Input details for software packages

The variance in the trends of input details for software packages is quite vivid once again. As illustrated in Figure 4-20, risk database is the prime type of input for software users in Pakistani construction industry, whereas risk register begs this glory in the global construction industry. Although both these types of input contain similar kind and level of information regarding risk, their nature is the main difference: risk database is a shared and computerized database which may be online and is usually contributed by and accessible to multiple users simultaneously, whereas the risk register is more of a manually maintained record of risk and is proprietarily owned by individual organizations. This hints at the growing understanding in the Pakistani construction industry towards the need to collaborate to be able to face the challenge posed by risk affectively and collectively. Conversely, the players in global construction industry are past this phase; their attention is now towards more personalized and customized collection of risk information which usually is more focused in its nature – avoiding excessive and useless exposure to generic nature of information.

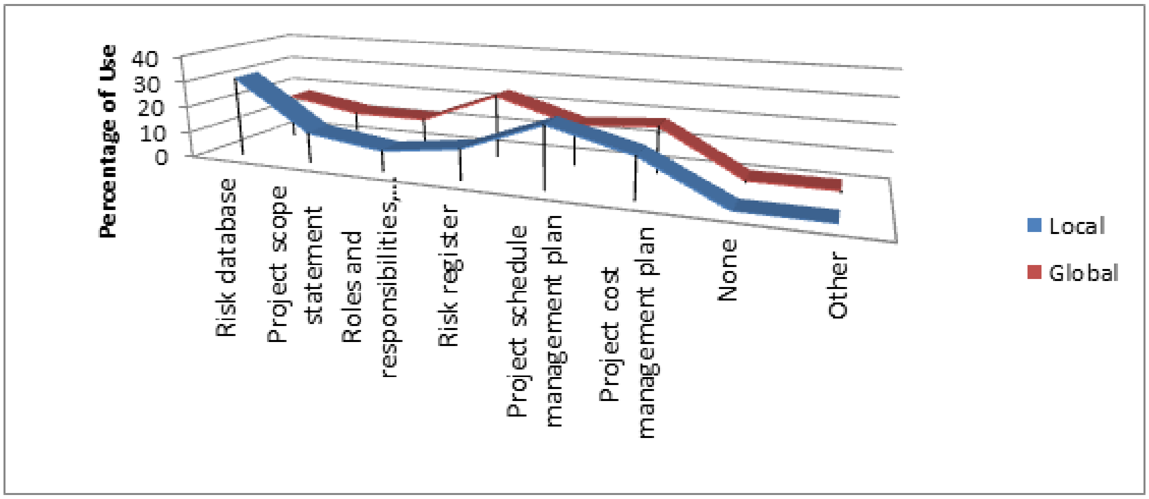

Figure 4-20: Trends of input details for software packages

Output understandability

The results obtained from the risk management software are not necessarily exact replies to close questions; they are complex numbers and probabilities which need to be interpreted. But before that, it may be required to post-process the results. As stated before, the sample of software using practitioners in Pakistani construction industry is too small for normal distribution and generalization as such; nonetheless the results hint towards better understanding by Pakistani participants compare to the global participants, as illustrated in Figure 4-21.

A total of 30% of risk using respondents in Pakistani construction industry report not needing any post-processing, the same is a little less for global construction industry. Although a little bit crude, the logic dictates that however less the penetration of software in Pakistan, it stipulates superior aptitude and capacity from the professionals involved in using these software. And owing to its smaller size, such requirement seems fulfilled, therefore the software tools employed serve a tiny bit more than the global construction industry where a little larger amount of post-processing has been reported.

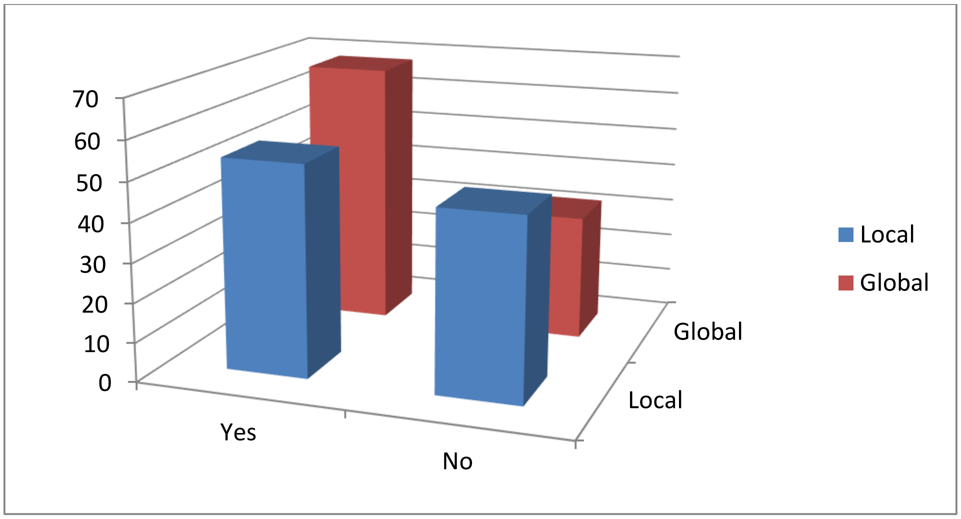

Figure 4-21: Trends of understandability of output from software packages

Output details for software packages

The type of output obtained by the global and Pakistani construction industries seems quite diverse: in Pakistani construction industry, where probabilistic study of the project and trends in quantitative study results seem leading the drift, the trend does not necessarily concur with that of its global counterpart where prioritized list of quantified risks and probabilistic achievement in cost and time objectives seem ahead, as shown in Figure 4-22.

The difference of trend may be attributed to the core objectives pursued by adopting these software tools. The global construction industry seems a tiny bit more mature than its Pakistani counterpart in the sense that their expected outcome from these software packages corresponds to more practical and relevant objectives such as probability of achieving time and cost objectives. Whereas in Pakistani construction industry, the objectives are still more of classic textbook cases: probabilities and trends. Academically, the purpose of software tools is to enable and facilitate the construction and project managers by allowing them foresight and outlook into the predictable (and unpredictable) future by analyzing the trends (of and with the help of past data). In this sense, the global construction industry seems to have comprehended and recognized the more practical aspects of the output and it also hints at the level of significance warranted to these tools. Pakistani construction industry, which though in theory seems to appreciate the most appropriate kind of output expected from the software tools, has yet a long way to go in order to master the craft.

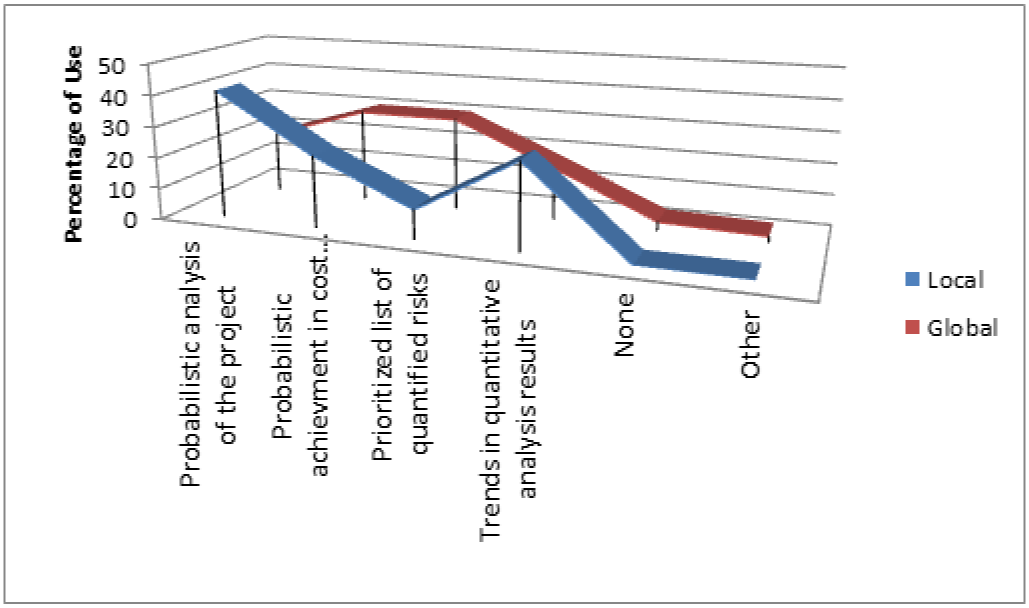

Figure 4-22: Trends of output details for software packages

Reasons for not using software packages

The justifications in opposition of these software tools also appear quite diverse between the two construction industries: although there seems a little agreement over cost, need of software and lack of product knowledge are most highly rated reasons in Pakistani construction industry; whereas in the global construction industry – apart from the cost – the sufficiency of tailoring is reported to be the most important reason, as illustrated in Figure 4-23.

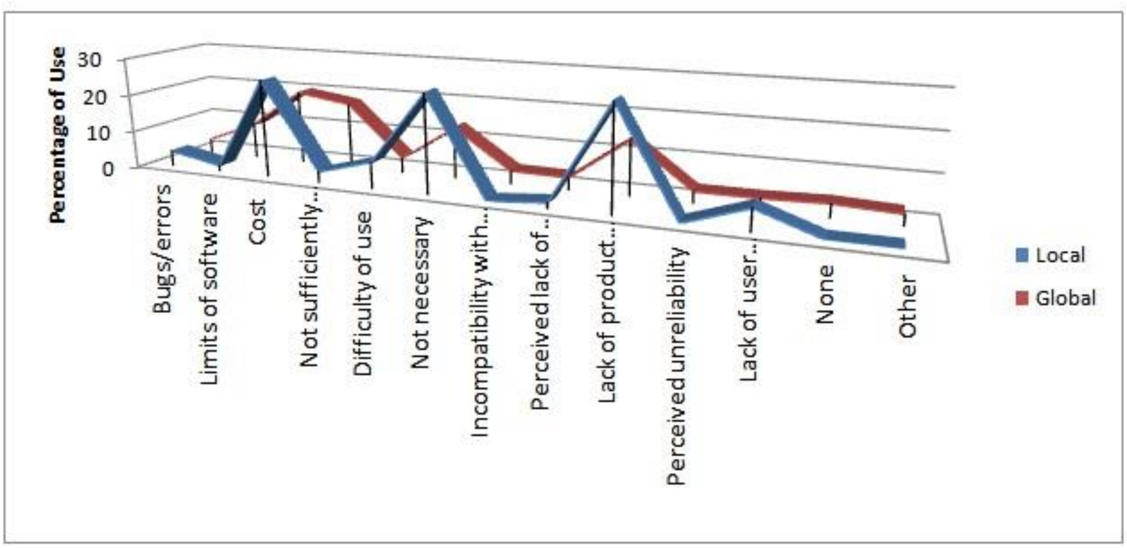

Figure 4-23: Trends of reasons for not using software packages

4.7: DISCUSSION, IMPLICATIONS AND CONCLUSION

Based on the participation of various PRM practitioners, the survey reveals the status of the PRM practice in the construction industry of 56 surveyed countries, along with the usage of various techniques and software tools. Results show that only 21% of respondents indicate the use of software tools for managing project risks. It was further observed that the cost of the software solutions is the largest barrier of implementation. Additionally, PRM software tools do not necessarily help the professional to the fullest: ranging from medium-to-high pre-processing and high post-processing, the survey observes that software tools may not be fully mature and thus their functionally may not be as robust as expected. It is also deduced from the survey results that there is still a high level of informality in the way professionals deal with the PRM process, depending upon the cost-quality-time tradeoff.

Project success may greatly be enhanced by a successful and effective PRM approach. Interpreting the results, it is perceived that either the complexity or lack of techniques and product knowledge motivate the global construction industry to use more qualitative and easily performable techniques. In turn, this reduces the efficiency of PRM process and, in spite of frequent risk management, the industry still faces uncertainties and the upsets occur.

The implications guide future research in the area of quantitative techniques, which may prove to be efficient as well as convenient for PRM professionals as almost all the PRM approaches suggest various processes and methods for analysis and management of project risk (Zhang, 2011). Thus, there is a need for exploring and improving upon the reasons and justifications for such a phenomenon. The survey results suggest that cost, sufficient tailoring of software tools and ease of gaining product knowledge are the main hindrances faced by a majority of professionals for not utilizing them. It may also be suggested to the designers and producers of such tools to improve the efficiency of tools because, as was reported by the survey respondents, the tools still perform a minimal amount of work and pre and post processing are usually required.

Based on these findings, it can be safely deduced that restoration projects, which are limited by their own kind of complexity, may benefit from some convenient and user-friendly penetration of risk management at the beginning. Although this means not gaining the most advantages, it is however safe to state at this stage that a simple and suitable introduction of PRM in restoration industry will not only motivate the practitioners but also help in countering the risk of its cancellation owing to its perceived complexity.

CHAPTER 5
CONSTRUCTION RISK TAXONOMY

Although the research in project risk management is phenomenal and a respectable industry diffusion has been claimed, both academic and industry perspectives, which are extremely critical to advancing this field, especially in risk identification and taxonomy, are not necessarily so well aligned. Thus there is a need to compare, contrast and even converge the understanding of both academia and industry in terms of perception of risk. Therefore a unique comparison and convergence of these perspectives was developed in order to understand the most relevant risks for projects and to ensure they are addressed in the risk management process. This comparison was created via a content analysis of the relevant literature and a survey to industry professionals. The differences and similarities among risks were analyzed, revealing that both perspectives emphasize financial/economic risks. The literature tends to focus on political; acts of God classified risks, whereas the industry places emphasis on regulatory risks. An elaboration of variations was performed aiming to improve the literature-based taxonomy taking into account the industry perspective to ensure its risk management process responds to these risks and provides a clearer focus towards future research. The apparent value addition from this work in the sector of restoration risk management comprises of understanding the possible gaps of perception between literature and prevailing practices, and come up with most relevant risk taxonomy for restoration projects.

5.1: OBJECTIVE

The common medium for the collection of industry perspectives is the survey. Prior to creation of this industry taxonomy survey, other surveys were analyzed on the topic of construction risk management. A preliminary review uncovered surveys with a primary focus on risk management practices and found that experience is the chief technique for individuals to identify and manage risks (Burchett *et al*., 1999; KMPG, 2012). Other surveys identified sector or country-specific risks rated based on criticality (Thomas *et al*., 2003). Additional surveys required respondents to rate risks based on importance and made an average rating visible (Choudhry and Iqbal, 2012). Tang *et al*. (2007) highlight and pinpoint some of the challenges in fifteen historical risk management surveys, such as lacking a multi-disciplinary perspective of risks, using an improper scale (such as a Likert scale of importance) and creating improper comparisons of priorities versus frequency risks. Confusion in perspectives and between an important risk and a frequently encountered risk (mutually exclusive qualities) can be encountered. Therefore, there are gaps in past surveys regarding the reporting of the risks most recently encountered on projects and the move to a more international perspective.

As a result of these identified survey gaps, it is also hypothesized that there is a difference between academic and industry perspectives regarding the prioritization of risks, making it difficult to determine the most important risks to address in new projects and future research. The purpose of this study is to answer the question-What are the different types of construction risks according to the literature and construction industry professionals' experiences? The objectives are to:

- Analyze the gap via a targeted literature review and content analysis
- Develop a framework taxonomy
- Create a literature-inspired risk matrix
- Distribute a survey to the industry to obtain an industry-inspired risk matrix from the results of the survey
- Build a comparison of literature-inspired and industry-inspired matrices and identify the risks recognized by both perspectives
- Elaborate and reflect upon the differences and similarities between the two perspectives
- Establish the implications and possible uses of this analysis

5.2: RESEARCH METHODOLOGY

In order to properly extract data from the literature, a type of textual or content analysis was carried out. Content analysis has been described as the collection, organization and structuring of information in a standardized format that enables the analysis and drawing of inferences from information to find meaning (GAO, 1996; Stemler, 2001). Historically, content analysis has been applied to investigate the existence or absence of concepts contained in a series of data in the social sciences and health studies (Pisano *et al*., 2011) and to identify trends that later become the basis of a survey. Thus, when the data under consideration is textual and the evaluations lead to useful comparisons; content analysis is a good approach (Stemler, 2001). The content analysis carried out here is more distinct, as information is written and from peer-reviewed journals versus interview data, case studies and related reports. The steps to the analysis were adopted as (GAO, 1996; Stemler, 2001): (1) define objective; (2) define material to be analyzed; (3) set units of analysis; (4) establish rules of coding; (5) check for reliability; (6) analyze and interpret the information; and (7) validate results. The purpose of this content analysis was to develop a matrix developed from the literature and framework taxonomy to become the basis of a survey to the industry and to compare to results of the survey. From the comparison of literature-inspired and industry-inspired matrices an explanation of the phenomenon of variance is provided.

5.3: CREATION OF THE TAXONOMY AND LITERATURE-INSPIRED MATRIX

The taxonomy was created via a general and targeted literature review that was performed regarding construction risk classification and taxonomies. The reviews uncovered 18 sources of literature (mostly peer-reviewed journal articles), as shown in Table 5-1, regarding the subjects of construction risk analysis, construction risks commonly encountered and general frameworks. Following the six steps to the content analysis (GAO, 1996; Stemler, 2001) the objective was uncovering what are the different types of construction risks encountered in construction projects according to the literature (development of a literature-inspired priority matrix) and the material to be analyzed was defined as literature that suggested the types of risks present in construction projects.

Author	Focus/Summary
Sun and Meng (2008)	Taxonomy for causes and effects
Hillson (2002b)	Proposed Risk Breakdown Structure (RBS)
Mustafa and Al-Bahar (1991)	Used the analytical hierarchy process
Leung *et al*. (1998)	A knowledge-based system
El-Sayegh (2008)	Risk assessment and allocation in the UAE
Akintoye and MacLeod (1997)	Risk analysis and management
Tchankova (2002)	Risk identification
Zhi (1995)	Risk management overseas
Chapman (2001)	Controlling influences in design management
Hastak and Shaked (2000)	International construction risk assessment
Dey (2001)	Decision support system
Dey (2010)	Used the analytical hierarchy process and map
Shen (1997)	Risk management in Hong Kong
Dikmen *et al*. (2008)	Developed tool for post-project assessment
Tserng *et al*. (2009)	Ontology-based, through project life cycle
Zou *et al*. (2007)	Key risks in construction projects in China
Tah *et al*. (1993)	Used linguistic approximation

Table 5-1: Construction risk identification taxonomy sources

A construction risk taxonomy matrix was created that divided risks according to three levels. While other risk matrices have divided the levels according to a variation of factors such as the location of risk, source and/or particular organization, the overall analysis ultimately discussed the sources of the risks (Dey, 2001; Shen, 1997; Tah *et al*., 1993; Zou *et al*., 2007). Therefore, the risks in this risk taxonomy matrix are divided accordingly into a combination of these classifications in Figure 5-1.

Level one classifies the risk as either internal or external to the construction vendor, level two categorizes the risk according to its source or organization responsible and level three captures the detail. Internal risks are those that are project related and usually fall under the control of the construction vendor and are then categorized according to the party who might be the originator of risk events such as owner, designer, and contractor.

External risks are those risks that are beyond the control of the construction vendor and are categorized according to a more macro perspective (Zhi, 1995). To properly organize and utilize large amounts of data, the Risk-Breakdown Structure/Hierarchical Risk-Breakdown Structure (RBS/HRBS) is commonly suggested (Hillson, 2002b); however, at this preliminary stage, a type of taxonomy (Sun and Meng, 2008) is utilized that focuses more on proper identification than a particularity priority.

The literature-inspired matrix followed the rules of coding according to the emergent principle (Stemler, 2001). To check for reliability, an external reviewer extracted a random sample of data and checked it against the sources.

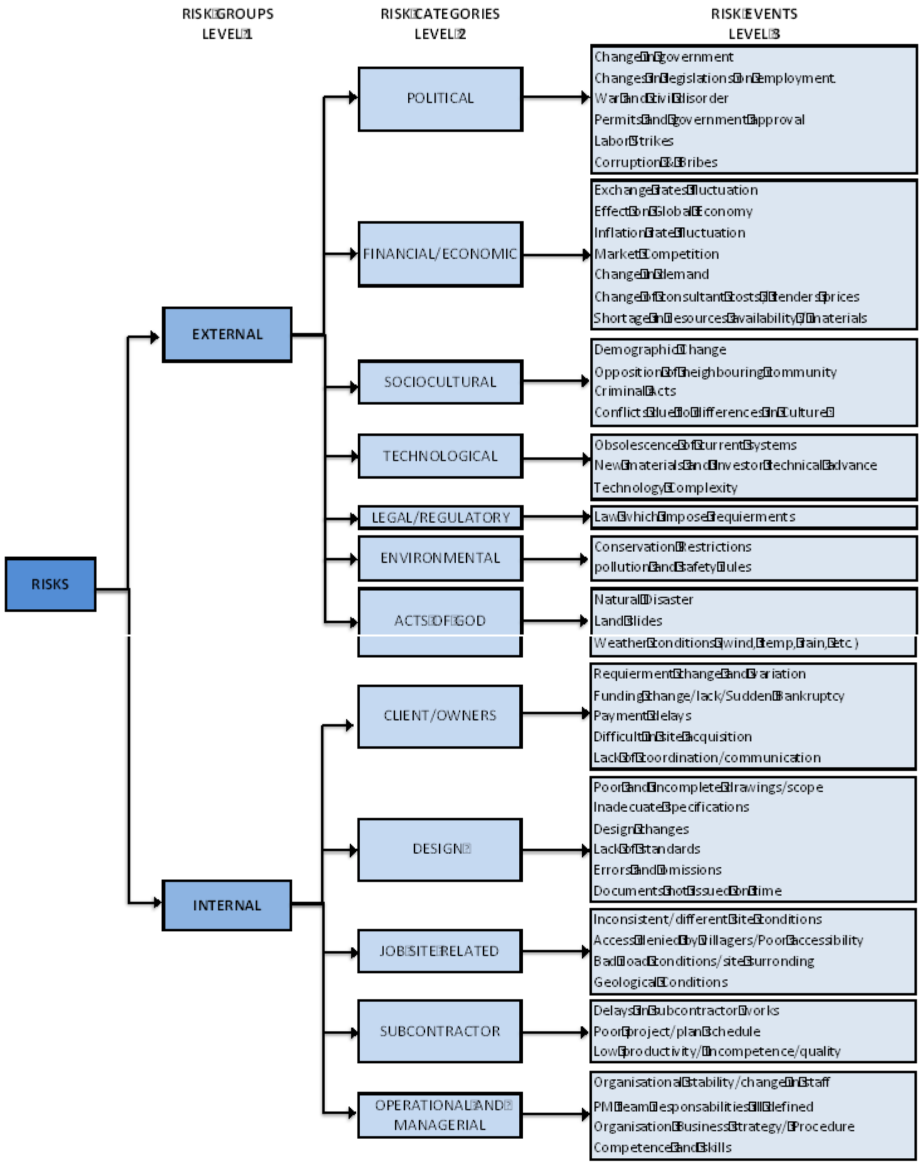

Figure 5-1: Proposed taxonomy

5.4: INDUSTRY SURVEY

An industry survey to construction professionals was created to uncover the most commonly encountered risks based on their past projects. The survey was made available online from March until May 2012 via social networks and professional emails. A total of 199 responses were received, which exceeded the required return sample size according to Cochran's (1977). A 7% margin of error was considered as acceptable given the norm of 5 percent for categorical data and 3 percent for continuous data (Krejcie and Morgan, 1970):

$$no = \frac{t^2 * p.q}{d^2}$$

Where:

no	=	Required return sample size
t	=	Value of selected alpha level
p.q	=	Estimate of variance
d	=	Acceptable margin of error

$$no = \frac{1.96^2 * 0.25}{0.07^2} = 196$$

$t = 1.96$ (α=0.05)

p.q = maximum possible proportion * (1- maximum possible proportion):

0.5*0.5 = 0.25;

d = 0.07

Overall, the results revealed that the respondents came from a variety of backgrounds (design/engineering and general contracting), are divided internationally and have high levels of experience (at least 15 years) in the construction sector. In detail, the types of companies were: design/engineering (33%); general contractor (31%); consultant (17%); subcontractor (4%); services (4%); and other (13%). Geographically, respondents came from the North and South America (62%); Europe (23%); Asia (9%); Africa (5%); and Australia (2%). The positions of the respondents were: engineer/designer (29%); project manager (27%); director (19%); Site manager (6%); project risk manager (2%); and other (18%). The years of experience were: greater than 15 years (45%); 15-11 years (13%); 10-5 years (20%); and less than 5 years (22%). Given the geographic position and the variety of respondents, bias of selecting samples can be reasonably avoided and the data collected can, to a large extent, be seen as representative of the general construction industry.

Internal risks		External risks	
Literature	Industry	Literature	Industry
Poor and incomplete Drawings	Lack of coordination/ communication	Inflation rate fluctuation	Permits and government approval
Low productivity/ Incompetence/quality	Design/scope changes	Exchange rates fluctuation	Weather conditions
Inconsistent/different site conditions	Payment delays	Shortage in resources availability/materials	Market Competition
Requirements change and variation	Poor and incomplete drawings	Changes in legislations on employment	Shortage in resources availability/materials
Funding change/ lack/Sudden Bankruptcy	Inadequate specifications	Natural Disaster	Change in demand
Lack of coordination/ communication	Requirements change and variation	Weather conditions	Law which impose requirements
Design/ scope changes	Delays in subcontractor works	Permits and government approval	Pollution and safety rules
Delays in subcontractor works	Documents not issued on time	Land slides	Change of consultant costs/tenders prices
Geological Conditions	Errors and omissions	Change in government	Effect on Global Economy
PM team responsibilities ill-defined	Poor project/ plan schedule	Obsolescence of current systems	Inflation rate fluctuation

Table 5-2: Risk comparison

Internal risks	External risks
Poor and incomplete drawings	Inflation rate fluctuation
Lack of coordination or communication	Permits and government approval
Design/scope changes	Shortage in resources availability/materials
Requirements change and variation	Weather conditions
Delays in subcontractor works	

Table 5-3: Highlighted Risks (in no particular order of importance)

5.5: INDUSTRY-INSPIRED MATRIX

After background information was collected, the survey asked the participants to identify the ten most common external and internal risks that they have encountered on their past projects. The industry-inspired matrix was created based on these results. Another survey carried out (Tang *et al*., 2007) validated these results, as it found the five most important risks to be somewhat similar as: poor quality of work, premature failure of the facility, safety, inadequate or incorrect design and financial risk. Therefore, it can be hypothesized that the rate of innovation and change in understanding and perception of risk is relatively faster in the industry than the literature. Preference change over time and under varied conditions; mostly aided by experience and exposure, which are readily available to the members of industry. Almost half of most frequently reported risks from industry point of view have only appeared over the last 5 years, suggesting a change of preferences and perceptions. Therefore, the survey results are validated on the industry side; however, they are missing a final comparison with the literature.

5.6: COMPARISON OF LITERATURE AND INDUSTRY MATRICES

After the literature-inspired and industry-inspired matrices were developed, the risks both perspectives identified were extracted. In comparing the matrices' top ten risks, it was found that not all risks in the literature matrix were in the industry matrix. In Table 5-2, the external and internal risks in common to both perspectives can be seen. Not only that, it was also found that the perception of industry and literature varies significantly on both external and internal risks as illustrated in Figure 5-2 and Figure 5-3, respectively.

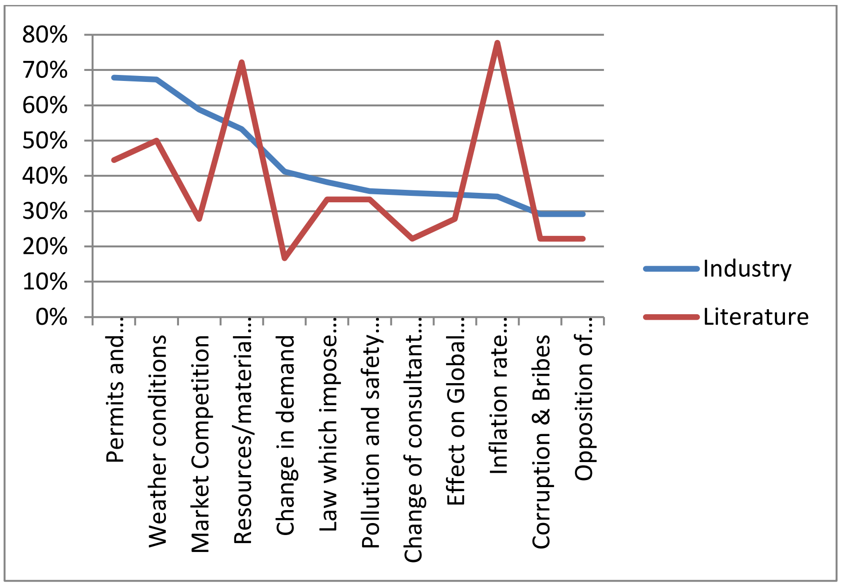

Figure 5-2: Industry v/s Literature: external risk perception

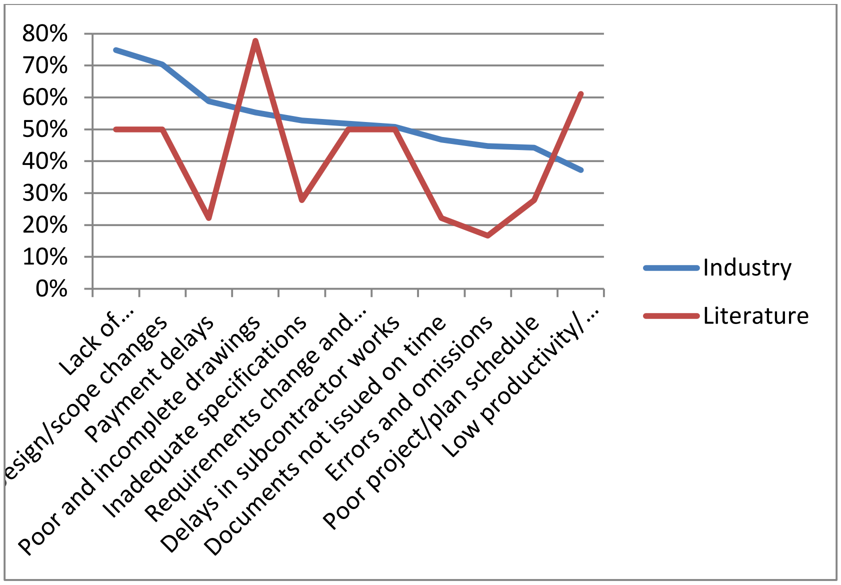

Figure 5-3: Industry v/s Literature: internal risk perception

5.7: ELABORATION OF RESULTS AND IMPLICATIONS

Patterns and relationships were investigated regarding the similarities and differences between the two perspectives, which uncovered some interesting findings. Comparing the risk categories with each risk uncovers that both perspectives see that external risks of the financial/economic type are most commonly encountered. Both literature and industry top ten matrices contained the external risks: permits and government approval, weather conditions (wind, temp, rain, etc.), shortage in resources availability/materials and inflation rate fluctuation. The internal risks commonly encountered were from the clients/owners and designers categories. Both literature and industry top ten matrices contained the internal risks: lack of coordination/communication, design/scope changes, poor and incomplete drawings, requirements change and variation and delays in subcontractor works (Table 5-3). The risks that were not common to both literature and industry and were not contained in the top ten should also be discussed to provide a complete representation and to gain insight into perceptions. The literature tends to have a greater emphasis on those risks pertaining to the external categories of: political and acts of God; whereas the industry emphasizes: regulatory and financial/economic.

For example, the financial/economic risks of: effect on global economy, market competition, change in demand and change of consultant costs/tenders prices were commonly encountered according to the industry, but did not make it to the literature top ten.

It can be argued here that the industry is more concerned with external risks relating to the economic environment, while the literature is more concerned with political risks such as change in government and legislations on employment. Also, it is evident that the industry sees risks relating to the economy as imminent and has a greater tendency to affect their projects than the government. Regarding internal risks that did not make it to the top ten, the industry saw design risk as commonly encountered, while the literature was concerned with job site related risks. It can be perceived that the industry is more concerned with the impact of third parties on their projects than that relating to the technical work, such as site conditions.

Further, the literature views the risk scenarios with a much wider lens whereas industry is more concerned by the immediate threats. Also the rate of renewal and up gradation of literature is less than that of compared to industry for obvious reasons. One such example is the explanation of ‘inflation risk’, ranked 1st by literature and 10th by industry: in the times of financial crisis, the inflation is controlled and the risk is reduced, decreasing its frequency and severity. Also, with experience, the industry has learnt to use sophisticated financial and contractual tools to control and manage this risk.

Further, literature seems to underestimate the otherwise ‘soft’ appearing scenarios, such as ‘human factor’ and ‘ground realities’, when it comes to prioritizing the risk. For instance ‘Lack of coordination/communication’, ranked 6th by literature and 1st by industry, establishes that the literature assumes such skills to be already provided with, being a bit too idealistic. Accordingly, strict coordination between the stakeholders may ensure timely and effective management of a number of risks; otherwise harmless looking factors can hugely contribute to major issues ranging from delays and cost overruns to severe accidents and physical damages. Furthermore, ‘weather conditions’, ranked 6th by literature and 2nd by industry, also demonstrates the hypothecation of literature: the ground realities are often more challenging than anticipated and a small change in weather condition may mean a huge impact on project execution, thus creating a potential loss.

5.8: CONCLUSION

This study addressed the gaps between academic and industry perspectives regarding the prioritization of risks, thus providing clarity to determine the most important risks to address in new projects and future research. Answers were provided to the central question “what are the different types of construction risks according to the literature and construction industry professionals’ experiences?”. Through literature and content analysis, framework taxonomy was developed and literature inspired risk matrix was created. Through the distribution of an international survey and the analysis of its results, an industry-inspired matrix was constructed and compared to the literature-inspired matrix. The similarities and differences were discussed. From this, industry and academia can benefit in working towards the development of risk management practices and tools.

The comparison performed and the resulting elaboration is significant as it combines dual perspectives and captures the critical components to be considered on future projects. Both industry and academic sides are portrayed. The comparison revealed that the original hypothesis that there is a gap between industry and academic perspectives regarding risks in construction projects is correct. The need to build a more complete, recent and industry-focused perspective of risk taxonomy was highlighted. A targeted literature review and content analysis lead to the development of framework taxonomy. The literature inspired matrix was populated by the responses from the survey. Finally, the comparison of these matrices revealed the commonalities and differences between perspectives of risk. Through the survey, analysis and matrices developed, the most important risks to address in new projects and future research were identified via a comparison of the two matrices and their detailed analysis.

Construction professionals can utilize these matrices to deliver practical risk management. They serve as a thinking tool or discussion prompt to ensure the team has looked at the project and its environment from different perspectives. The matrices do not encompass the entire risk management process, thus it is recommended that they are combined with other techniques. Future research should further explore financial/economic and client/owner risks, establishing methods to mitigate these frequently encountered risks. Future industry surveys should seek to obtain a larger sample size, use multiple languages and mediums to reach out to a larger population of construction industry professionals.

Part-2

PRM in the Cultural Heritage Restoration Projects

CHAPTER 6

SELECTION OF RISK ANALYSIS TECHNIQUE

This research advocates and proposes a project risk management framework for the restoration projects of built heritage on the basis of lessons learnt from construction industry. At the core of framework is the proposal of risk analysis techniques. But before getting to that part, it is imperative to understand how the proposed techniques are selected, what is their rationale and possible value addition into the general management context. Project Risk Management (PRM) is gaining attention from researchers and practitioners in the form of sophisticated tools and techniques to help construction managers perform risk management. However, the large variety of techniques has made selecting an appropriate solution a complex and risky task in itself. Accordingly, this chapter proposes a practical framework methodology to assist construction project managers and practitioners in choosing a suitable risk analysis technique based on select project drivers. Additionally, the methodology transforms the traditional triple constraints by broadening the focus from the project to a combination of the project and PM organization. Scale harmonization is achieved by dividing the selected project drivers and risk analysis categories into four levels. The applicability and efficiency of the methodology is demonstrated in two actual construction projects by creating a radar chart and performing their ex-post risk analysis with the help of the developed technique. The study contributes to the existing body of knowledge on PRM as a practical tool that helps project managers select suitable risk analysis techniques under given project characteristics.

Of the constituent elements of risk management, one of the most important is risk analysis. Despite recognizing the importance and utility of an intuition-based "experimental system" of risk analysis (Slovic *et al*., 2004), it is still crucial to use algorithms and normative rules to attempt to create an "analytic system" (PMI, 2009). In particular, the analysis of risky situations in construction projects is a critical challenge for any construction project manager and further critical is the selection of an appropriate technique to assist project risk analysis (Baloi and Price, 2003). In fact, there is no universally accepted way to assess risks in all projects; the literature is full with a number of techniques (Dikmen *et al*., 2008), all claiming to be mathematically, statistically and from an engineering point of view, extremely competitive and effective. However, choosing the most suitable risk analysis technique for given project characteristics is critical to project success.

In an attempt to help project managers choose the appropriate project risk analysis technique, this chapter proposes a framework methodology for selecting a specific qualitative or quantitative risk analysis technique under given characteristics of the project being managed.

6.1: PROJECT DRIVER DESCRIPTIONS

Tacit knowledge dictates to use specialized techniques where needed: high-risk projects require more sophisticated techniques and resources as contrast to small, low-risk projects (Ward, 1999). Such as, it seems reasonable to assign the experienced project managers at large, high-risk projects. Also, high-risk projects should be more carefully planned, closely monitored and strictly controlled (Couillard, 1995). In other words, a high level of risk requires a scrupulous project risk analysis and the best risk management techniques vary widely according to project characteristics.

A project may be characterized by a number of important drivers (dimensions), where each driver underlines a significant feature of the project. The traditional *triple constraint* (time, cost and quality/scope) of projects has already been proven to be inadequate (Norrie and Walker, 2004) and work has been conducted on determining additional and robust project dimensions (Shenhar *et al*., 1997). Moving forward with the detailed work of Pich *et al*. (2002) indirectly, it is proposed that a project can be described as driven by the following four main dimensions (or drivers), represented on the four axes of the radar diagram: its level of challenge, the responsibility of the PM considering the size of the scope of work, the focus on one or more phases of its life-cycle and the level of maturity of the project management processes of the PM organization. The combination of these four factors allows one to conveniently frame the project into objective drivers of project risk. For example, a highly complex and large-sized project is likely to bring a high level of risk, which requires sophisticated risk analysis techniques.

The four abovementioned project drivers are discussed in further detail in following parts.

6.1.1: Challenge

Every project is a challenge and requires certain competencies for effective execution (Lampel, 2001). A broad range of technological or otherwise attributes define the level of challenge of a project, such as technological difficulty of task performance, differentiation and interdependency of operations, e.g., overlapping design and construction (Baccarini, 1996).

Here, the concept of being challenged with complexity in a project encompasses these definitions, with four levels of increasing challenge/complexity that can characterize a project (Shenhar and Dvir, 2007): (1) the uniqueness of the constructed facility; (2) the innovation of the building technology or of the construction process; (3) the complexity of the system design and its subsystem assemblies; and (4) the criticality of the time frame requiring a fast pace and time-critical construction effort. Therefore, a highly complex construction project can be a unique, complicated system design that uses breakthrough technology and requires a rapid development process.

6.1.2: PM Responsibility

Project scope, along with other key aspects, is a crucial stage, where risks associated with the project are analyzed and the specific project execution approach is defined (Ward, 1999). The success of a project is highly dependent on the level of effort expended during this scope definition phase (Cho and Gibson, 2001) and the scope size is an important factor influencing the number and impact of risks on a project.

The project scope and the associated inherent risk can be measured via four escalating factors: (1) the number of tasks required to accomplish the project; (2) the number of resources assigned to the tasks; (3) the magnitude of the budgeted/actual cost; and (4) the financial stress of the project's cash flow. Thus, a large-sized project will have a large number of tasks with many assigned resources which results in a huge budget with deep financial exposure that demands anticipated equity capitals (Miller and Lessard, 2001).

6.1.3: Focus

It is important to consider the purpose and coverage of the management effort before managing a project because it allows an understanding on whether focus is needed at a single stage of the project or goes throughout the full project lifecycle. The process implies a notion of gradually increasing detail and focus on the provision of the final deliverable. This, in turn, may prove to be instrumental in addressing the inherent uncertainty attached to the fundamental question of 'what and how much to be done (Ward and Chapman, 2003) ?'

A project can be addressed to cope with the following four main focuses, ranging from limited to extended: (1) proposal preparation during a bidding process; (2) either pure design or sole construction; (3) integrated design and construction and (4) lifecycle, which is usually a combination of the first three stages, namely design, construction and operations (Arditi and Gunaydin, 1998). A lifecycle focus is likely to bear more associated risks.

6.1.4: Maturity

PM organizations that undertake projects are always required to improve and adjust their operations and processes to plan, manage and complete projects more successfully due to constant pressure on project managers to integrate, plan and control complex projects (Ibbs and Kwak, 2000). Project organizations are exposed to maturity models of various types (Grant and Pennypacker, 2006). Furthermore, not only does the organizational project management maturity matter but also the risk management maturity of the PM organization.

PMI (2008a) identifies the organizational project management maturity on four scales: (1) standardize the process; (2) measure the effectiveness of the standardized business processes in achieving desired outcomes; (3) control the developed processes, plans and implementations to achieve stability and (4) continuously improve by identifying new problems and implementing improvements to attain sustainability.

6.2: PROJECT RISK ANALYSIS TECHNIQUES

The process of project risk analysis demands appropriate and efficient techniques. A technique is a specific procedure designed to perform an activity or to solve a problem under a prescribed notation and guidelines (Brinkkemper, 1996).

The application of a risk analysis technique is often supported by tools that can be automated. The main role of the tools is to allow for searching, gathering and managing the necessary data for the various PRM phases. Various techniques use different types of data and information collected from a wide range of sources using different tools, such as statistics, inspections, surveys, documentations and expert judgments (Gilbert, 1989).

Project risk analysis techniques can be classified into two main categories, namely qualitative and quantitative techniques (PMI, 2009), with associated sub-categories of semi-quantitative and simulation techniques. The group of qualitative risk analysis techniques does not operate on numerical data, presenting results in the form of descriptions, recommendations and ordinal scores (Hubbard and Evans, 2010), where risk assessment is connected with qualitative description and determination of qualitative scales for the probability and impact of the consequences of risk. Qualitative techniques can be lists of risks, risk rankings, or risk maps. These techniques prioritize risks for subsequent further analysis or action by assessing and combing their probability of occurrence and impact. The risk is evaluated in more conceptual terms, such as high, medium or low, depending on the collected opinions and risk tolerance boundaries in the organization.

The main qualitative analysis techniques are: brainstorming: best possible solutions of project risk are generated and determined under the leadership of a facilitator (Berg, 2010); cause and effect diagram: also known as the Ishikawa or fishbone diagram, it is useful for identifying and analyzing causes of risks (Del Canõ, 2002); checklists: a detailed aide-memoire for the identification of potential risks based on past similar projects (Del Canõ, 2002); delphi: a facilitator uses a questionnaire to solicit ideas about the major project risks and project risk experts participate anonymously (Berg, 2010); Event Tree Analysis (ETA): Models the range of possible outcomes of one or a category of initiating events and usually provides qualitative descriptions (Del Canõ, 2002); Risk Breakdown Matrix (RBM): An 'activities and threats' matrix, where the risk number for each activity and the most frequent overall risks are evaluated (Hillson *et al*., 2006); risk data quality assessment: Evaluates the extent to which a risk is understood and the accuracy, quality, reliability and integrity of the risk data (PMI, 2009).

A derivative group of techniques is the one that uses a semi-quantitative assessment of risk. Semi-quantitative analysis can be defined when a scale factor is associated to nonnumeric rankings.

Some of the semi-quantitative variants of qualitative techniques are: Interviewing: Risks are identified through expert interviews and a risk management capability score is determined with a five-point scale. This technique is also used to assess the probability and impact of risks on project objectives (IMA, 2007); risk mapping, risk matrix, probability and impact matrix: used to semi-quantitatively evaluate and prioritize a group of risks that could significantly impact the project cost and time outcomes (Scandizzo, 2005); risk probability and impact assessment: Investigates the likelihood and potential effect of a risk on projects objectives (PMI, 2009).

With quantitative analysis techniques, the estimation of risk exposure is related to the application of numerical measures. Here, the impact of consequences is defined as a monetary value and the likelihood by the frequency of risk occurrence based on past series of available data. In brief, quantitative techniques numerically analyze the effect of identified risks on the project objectives (PMI, 2009).

The main quantitative techniques are: decision tree analysis: a decision flow diagram subject to the influence of future events with a known probability of occurrence (Schuyler, 2001); expected monetary value: takes into consideration the probability aspect of the system states and is based on a gain matrix (PMI, 2009); expert judgment: Based on expert opinions to evaluate the failure rate and success chances of the overall project (PMI, 2009); Fault Tree Analysis (FTA): Possible derivative risk events are derived from a top event (Del Canõ, 2002); fuzzy logic: A simple way to reach a definite conclusion based on vague, imprecise, noisy or missing input (Konstandinidou et al., 2006); probability distributions: continuous probability distributions represent the uncertainty in values, such as durations of schedule activities and costs of project components (Del Canõ, 2002; PMI, 2009); sensitivity analysis/tornado diagram: helps to determine which risks have the greatest potential impact on the project. Using a Tornado diagram, an attempt is made to capture how much risk impacts a particular metric, such as revenue or earnings (Lyons and Skitmore, 2004).

In addition, risk analysis techniques that use computer-based simulation tools, such as Monte Carlo simulations and system dynamics applications for PRM, can be considered derivative concepts of quantitative analysis techniques because of the extended use of numerical past data for risk analysis. Simulations are of great value when large sets of historical data from past projects are available.

Some of the techniques in this category are: Monte Carlo: evaluates decisions related to future events that can be described with probabilistic distributions. Monte Carlo simulations randomly choose values for uncertain variables to generate a distribution of possible case scenarios (De Marco, 2011); system dynamics: allow for diagramming a system of causally looped variables, defining the mathematical relations and instructing a computer to solve the differential set of equations with the purpose of assessing the impact on project performance.

6.3: A REVIEW OF QUANTITATIVE ANALYSIS TECHNIQUES

A good deal of qualitative and quantitative risk analysis techniques, along with identification and monitoring and control techniques, with respect to PMI's project risk management model, have been addressed in Chapter 2 (Support Elements to the Project Risk Management). However, PMI does not necessarily cover all possible techniques which are being used for (qualitatively or quantitatively) analyzing the risk. As mentioned in the previous sections as well, the quantitative risk analysis is considered extremely robust due to the precision and reliability of results is yields. However, the complexity of calculation and high demand regarding the precision and relevance of input data do considerably bound the penetration of these techniques. Notwithstanding this criticism, the theoretical superiority of these techniques is accepted.

The comprehensive literature review was carried out for 16 quantitative risk analysis techniques. They are described in subsequent sections.

6.3.1: Bayesian Method

Bayesian method, based on the theorem presented by Reverend Thomas Bayes in 1764, offers "the possibility to use personal and objective probability estimates changing as new data appear as elements of uncertainty are numerous, subjective and may be revised, following the acquisition of information" (Van der Acker, 1996, 71). Bayesian models have developed procedures to revise probability by changing the initial values based on experimental results. The probability of an event is conditional on another event unknown or uncertain (Anderson et al, 1999).

6.3.2: Belief Functions Method

Belief Functions method comes from the Dempster-Shafer theory, which is a generalization of Bayesian theory of subjective probability. This method allows combining evidence sources and arrives at a degree of belief that takes into account all the available evidence even though when sufficient information is not accessible (Pearl, 1990). Belief, in a hypothesis, is constituted by the sum of the masses of all sets enclosed by it. Belief (denoted by 'Bel') measures the strength of the evidence in favor of a set of propositions. It ranges from 0(no evidence) to 1(certainty) (Shafer, 1976).

6.3.3: Decision Making Matrix

A decision making matrix, also known as risk matrix, is a graphical tool that combines information such us the chance of occurrence of an event and the consequences of the event (if it occurs) for quantifying risk as the product of both concepts. This tool is easy and quick to use and is therefore preferred (Barringer, 2008). The main objective of decision matrix is to evaluate and prioritize a list of options by establishing a list of weighted criteria for the evaluation of each option. It is very simple and is principally based on expert judgment and some simple calculations for obtaining the results of the matrix. A lot of subjectivity in this process may be found which calls for experienced and prepared participants (Mullur et al, 2003).

6.3.4: Decision Tree Analysis

Decision tree analysis is a graphic technique that involves considering different situations and the implications of each scenario, and compares them for choosing the best option in each case. It includes the cost of each choice, the probability of occurrence and with that, it assigns a value, an outcome (Olivas, 2007). Decision trees provide a highly effective structure within which the options may be laid out and the possible outcomes of choosing those options can be investigated. Decision tree analysis helps in forming a balanced picture of the risks and rewards associated with each possible course of action (Dey, 2002). The decision tree analysis technique can be applied to many different project management situations. In risk management, there are some types of risk that decision trees are capable of handling and others that they are not. In particular, decision trees are best suited for risk that is sequential (Hulett, 2006).

6.3.5: Expected Monetary Value (EMV)

Expected monetary value analysis is a statistical concept that calculates the average outcome when the future includes scenarios that may or may not happen (PMI, 2009). EMV is a tool for risk quantification that is the product of two numbers: risk event probability and risk event value (Raftery, 1994). It takes into account all possible outcomes and the probabilities of each alternative decision or strategy.

Multiplying each possible outcome value with their probability and adding all the results together may help obtain the total result. This value is positive for opportunities and negative for threats (Stefanovic and Stefanovic, 2005).

$$EMV = \sum_{n-1}^{N} Value_n \times Probability_n$$

6.3.6: Failure Mode and Effect Analysis (FEMA)

Failure mode and effect analysis is a quantitative tool that consists of evaluating potential process (or a product) failures, evaluates risk priorities and helps determine and assess the impact of those causes, with the purpose of avoiding identified problems. Questions like "what are the things that can go wrong?", "why would the failure happen?" and "what will be the consequences of each failure?" are the ones that can help us for applying this method (Lutz and Woodhouse, 1999). Once risks are identified, project team members need to assess the extent to which existing control mechanisms or procedures are likely to detect the cause of failure before it occurs or before its effects occur, allowing time for taking corrective actions (Snee and Rodebaugh, 2008). So, this technique is used for two main reasons: to prevent an extra cost of design modifications by discovering problems in the initial design and operational deficiencies, and to reduce errors throughout the project development (Carbone and Tippett, 2004).

6.3.7: Fault Tree Analysis (FTA)

Fault Tree Analysis was developed in 1962 for the U.S. Air Force by Bell Telephone Laboratories for the use of Minuteman system (Rechard, 1999). It is a graphic model of the pathways within a system that can lead to a foreseeable and undesirable loss event. The pathways interconnect contributory events and conditions, using standard logic symbols (Clemens, 2003); so, it represents the various combinations (parallel or sequential) of possible failures and interrelated logic of events leading to the undesired event (Stamatelatos and Vesely, 2002). It is important to understand that a fault tree is not a model of all possible system failures or all possible causes for system failure (Ortmeier and Schellhorn, 2006).

6.3.8: Interviewing

Interviewing techniques are employed to assess probabilities and the impact of achieving specific objectives based on input from relevant stakeholders and subject matter experts. In the interview, it is always a good mix to obtain the optimistic (low), pessimistic (high), and most likely scenario for a given objective (Kerzner, 2003). The experience of some risk practitioners has led to an estimate that the project manager might be able to identify 60-80% of foreseeable risk through use of a structured interview approach (Hillson, 2004).

6.3.9: Monte Carlo Method

Monte Carlo method got its name as the code-word for work that Von Neumann and Ulam were doing during the World War II at Los Alamos for the atom bomb, where it was used for integrating mathematical functions (Vose, 2008; Salling, 2007). Thus, it exists approximately since 1940's where roulette game was a good example for random number generation and was very famous in the casinos of Monte Carlo (Monaco). However, until the increase of computer technology and power, it did not become the most used technique (Pengelly, 2002). Monte Carlo method is the application of laws of probability and statistics to natural and physical sciences. What make it particular are those various distributions of random numbers which reflect a particular process in a chain of processes (Anderson, 1986). It is a method of investigating the effect on a strategy of the main risks as simultaneous and non-linear interaction may have an effect on the otherwise nominal or already settled results (Hulett, 2004).

6.3.10: Program Evaluation and Review Technique (PERT)

Program Evaluation and Review Technique is a useful tool for scheduling, organizing and coordinating different tasks in a project. It was developed mainly to simplify the planning and scheduling of large and complex projects (Malcolm et al, 1959). One of its aims is to statistically estimate, with a determined probability and range of values, the amount of time for otherwise uncertain project tasks (ADEAK, 2011). It's used when there is an uncertainty in the durations of project activities (Klastorin, 2003).

6.3.11: Probability Distributions

Probability distributions describe how probabilities are distributed upon events. The word probability can be defined as "a measure of the relative frequency or likelihood of occurrence of an event, whose values lie between zero (impossibility) and one (certainty)" (Simon et al, 1997). Probability distributions are used to graphically illustrate risk probability, representing the probability density functions. For each probability distribution, the vertical axis indicates the probability of the risk event and the relative likelihood, and the horizontal axis depicts the impact (time or cost) of the risk event (Evans et al, 2000).

6.3.12: Scenario Analysis

Scenario analysis is a process of analyzing and estimating possible future events, considering various alternatives. It is used to manage risks and develop robust strategic plans in the face of an uncertain future (Hsia et al, 1994). Generally, scenario analysis is done for evaluating the financial or economic aspect of a project, so, it also can be defined as the estimation of the expected value of a portfolio after a given period of time, assuming specific changes in the values (McBurney and Parsons, 2003). It helps in managing risks, building consensus for change, augmenting understanding about the future, and monitoring progress and scanning changes in the environment (Maack, 2001).

6.3.13: Sensitivity Analysis

Sensitivity analysis helps in determining which risks have the most potential impact on the project (PMBOK, 2008). It is used to figure out how "sensitive" a model is to varied input parameters of the model and to changes in its structure (Saltelli, 2004). This can be done by varying the values of one input and observing which of the outputs change and how this change affects the project objectives. It tries to provide a ranking of the model inputs based on their relative contributions to model variability and uncertainty. It also can be defined as "the assessment of the impact of changes in input values on model outputs" (Frey and Patil, 2002) or as "the study of how the variation in the output of a model can be apportioned, qualitatively or quantitatively, among model inputs" (Saltelli et al, 2000).

6.3.14: Fuzzy Logic

Fuzzy logic was first suggested in 1965 (Zadeh, 1965) to cover those situations that require an approximate reasoning about the solution rather than accurate. It is characterized by adapting to the real world, i.e. it quantifies the belongingness for values by linguistic concepts (Abdelgawad and Fayek, 2010). Fuzzy logic possesses the ability to mimic the human mind to effectively employ modes of reasoning that are approximate rather than exact. It is one of the tools used to model a multi-input or multi-output system (Biacino and Gerla, 2002).

6.3.15: Analytic Hierarchy Process (AHP)

Analytic Hierarchy process, developed by Thomas Saaty in the 1970's (Saaty, 1980), is a method for organizing and analyzing complex decisions and is based on mathematical and psychological sciences. It helps in solving complicated decision problems taking into account tangible and intangible aspects. Thus, involves the experience, the knowledge and the intuition of the decision makers (Forman and Gass, 2001). It involves a classification of decision elements and their corresponding alternatives, weighing each of the elements and making comparisons between possible pairs of each group (matrix). It is very useful in decision-making, where teams of people are working on complex decisions with high risks and uncertainties and, additionally, implicates human perceptions and judgments, with long-term repercussions (Bhushan and Raj, 2004).

6.3.16: Break Even Analysis

Break-even analysis is a useful tool to study the relationship between fixed costs, variable costs and returns. This technique is also known as cost-volume-profit analysis. It is widely used by production management and management accountants (Schweitzer et al, 1992; Guidry et al, 1998). It is a continual way of thinking used by people potentially everywhere in the organization as it deals with a variety of decisions (Cafferty and Wentworth, 2011). It is based on mathematics: it is the quantity of units that must be sold to achieve breakeven point (Richards, 2011).

6.4: METHODOLOGY

The four categories of risk analysis techniques can be plotted according to their degree of analytic assessment of risk exposure, from qualitative analysis to simulation. It can be argued that quantitative and particularly simulation-based techniques require a larger effort to gather and process data compared with qualitative assessment techniques. Consequently, quantitative techniques are likely to be applied in projects with a greater level of risk. The idea is graphically demonstrated in Figure 6-1, where the four categories of risk analysis techniques are incorporated with the four project drivers discussed in previous sections.

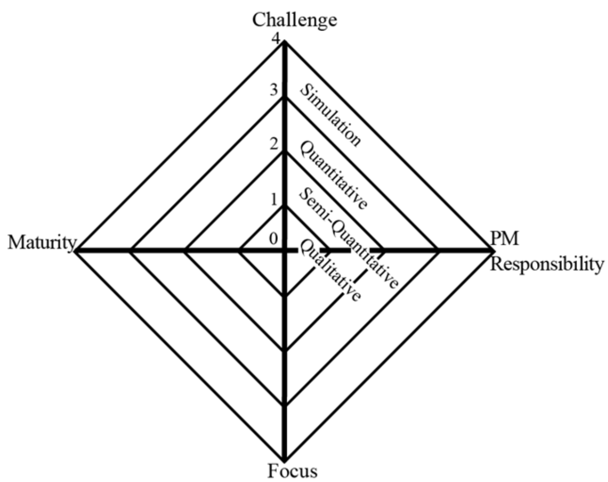

Figure 6-1: Categories of risk analysis techniques incorporated in the radar diagram

Plotting the project drivers on the chart results in determining the risk analysis technique category; this is suitable for the given variables.

It is imperative to mention that all projects do not necessarily demonstrate a ‘balanced’ feature on the radar diagram: certain dimensions may be more skewed and stretched than others, rendering a poorly adjusted and unbalanced diagram. In such situations, it is always advisable to consider at least the plotted area (category of risk analysis technique) covered by joining all four ends. Furthermore, a middle ground is suggested as a compromise because the dominance of ‘Maturity’ must be considered because a less mature PM organization might not be in a comfortable position to use sophisticated techniques. Therefore, an informed ‘subjective’ decision may be made in such cases.

In other terms, the extension of the project plotted area on the four dimensions diagram is an indicator of the extent to which quantitative techniques might beneficially apply to the risk analysis process.he radar diagram.

6.5: DEMONSTRATION PROJECTS

To practically demonstrate the applicability of the proposed methodology, reported below are two projects from the direct experience of the author involved as construction consultants/experts. The projects were selected based on the differences in their radar diagram, which provides a better understanding of how to select a certain category and/or meet halfway.

6.5.1: University Campus Project

Project Overview

This first sample project is about the development of a new educational facility in the city center of Turin, Italy (Università Di Torino, 2012). In 2006, the university engaged the service of a Build-Operate-Transfer concessionaire to design, secure permits, finance, build and maintain the facility, which consists of more than 17,000 square meters of above ground functions (lecture rooms, office buildings, dormitories, kindergartens, support stores, commercial services) and more than 20,000 square meters of underground facilities (parking lots, a gym and a swimming pool). The private investment of € 40 million will be reimbursed via an annual unitary charge payment by the university, including all facility management services and rental fees obtained from operating the commercial and parking functions. An initial public funding of approximately € 6 million is made available.

Project Risks

Here is a short description of what happened and the major obstacles incurred during the course of action. The project, up to May 2012, has undergone various major risks, namely, design changes due to varied rental market conditions following the 2007/08 real estate crisis; the design not being approved by the fire protection agencies due to design changes; archeological discoveries in the underground excavations; financial stress due to the 2010/11 credit crunch with escalation in interest rates; financial problems of the leading company; no equity available to fund the design period up to the financial closure and ground breaking; an experienced project manager quitting at a crucial stage of the design development; level of bankability lower than expected; changes in the pre-agreed term sheet of financial closure; increase in unexpected financial closure transactional costs; lack of investment funds interested in entering the SPV capital; financial problems of the university; changes in the BOT system regulation in Italy;

underperforming commercialization/lower level of expected market revenue; difficulty in finding interested gym and swimming pool operators; and increased level of dispute between the project partners.

Project Mapping on the Radar Chart

The project is identified on the anticipated radar diagram's axes (Figure 6-1) as follows: Challenge 3, PM Responsibility 4, Focus 4 and Maturity 1. The medium-high level of challenge is due to the interconnection of various systems and buildings devoted to the different functions. However, the project is neither time critical nor at a high level of innovation in building technology and process.

Because the project is a privately financed public facility, the Special Purpose Vehicle (SPV) company has tremendous pressure on the cash stream, which becomes extremely critical when the financial closure is secured with the banks' pool. The focus is on the total BOT life cycle from the initial concept design to operations. Finally, the medium-sized family owned company, which holds 75% of the SPV and associated project's design and construction efforts, is at a low level of maturity in the project management because there are not refined methods for measuring, controlling or continuously improving the performance of their project management processes. The project drivers are plotted on the radar diagram in Figure 6-2. The project poses an 'unbalanced' mapping on the radar chart.

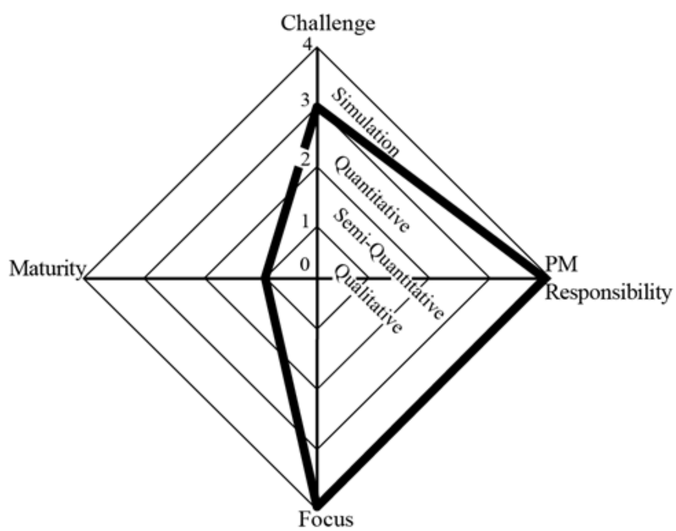

Figure 6-2: Dimensions of the university campus project on the radar diagram

It suggests that quantitative techniques be used, not a simulation due to the level of challenge. However, the extremely low level of maturity results in an even lower sophisticated category of techniques, which is more aligned with acceptance/expertise and usage. However, using only qualitative techniques would be too simplistic and unjustified: aligned with the level of maturity but not adequate for high levels of other drivers. Thus, it is proposed to use the semi-quantitative category and it is further proposed to use the "Probability-Impact Matrix" technique.

Risk Analysis

In Table 6-1, the risk analysis is performed using the data of the project during the year 2008 with the help of the selected technique.

N.	Description	Prob.	Impact	What occurred	Risk Rank
1	Design changes due to varied rental market conditions	2	5	Market crisis	H
2	Design not approved by permit authorities	1	4	Firemen	L
3	Archeological discoveries in the underground excavations	4	2	Unknown 9th century walls	L
4	Increase in interest rates charged by lending institutions	4	5	World credit crunch	H
5	Financial problems of the leading company. No equity available to fund the design period up to the financial close/ground breaking.	3	4	Bankruptcy	H
6	Project manager turnover	1	4	Quit when company started having problems	L
7	Liquidity due to crisis	3	5	Lower level of bankability than expected. Pre-agreed term sheet of financial close changed. Increase in unexpected financial close transactional costs (business planning, banks' due diligence). No investment fund interested in entering the SPV capital.	H
8	Granting authority's budget cuts	4	3	Financial problems of the university meant incapable of paying the additional annual charge to assure the project's bankability	M
9	Changes in the BOT system regulation in Italy	3	2	The project was not affected	L

10	Revenue/market risk	2	4	Underperforming commercialization/lower level of market revenue. Unable to find an interested gym and swimming pool operator due to the financial crisis and high level of fees demanded by the business plan to assure profitability	M
11	Stakeholders' dispute	2	5	Increased level of dispute between the project's partners	H

Probability Scale: 1 – Very Low, 2 – Low, 3 – Medium, 4 – High, 5 – Very High
Impact Scale: 1 – Very Low, 2 – Low, 3 – Medium, 4 – High, 5 – Very High
Risk Rank Scale: H – High, M – Medium, L – Low

Table 6-1: Risks and application of the semi-quantitative Probability-Impact Matrix technique

Also, based on the "Probability and Impact Risk Ranking" (PMI, 2009), the risks have been categorized into 'High', 'Medium' or 'Low' risks.

Discussion

The use of a simple and less sophisticated technique results in a less than thorough but at least, a guaranteed risk analysis, which otherwise could be ignored. Additionally, the conventional risk ranking serves the purpose of risk analysis because it draws the management attention towards critical aspects of the project, which if mitigated and managed intelligently, will result in a higher probability of project success. Apparently, it seems evident from the current scenario that the most serious risks of the project were actually the ones with high ranks obtained from the analysis. Therefore, it can be safely assumed that the technique selected using the radar diagram given the project drivers proved to be apt and sufficient for the risk analysis.

The project manager, when requested to provide feedback of this analysis, concluded that the methodology is viable and useful in selecting risk analysis techniques that are suitable for the level of the project complexity and maturity of the project environment. The project manager stated that this methodology does not provide an unnecessary managerial burden to the project management duty. On the contrary, the methodology helps to provide the right tools for the right project.

6.5.2: Container Yard and Quay Wall Expansion Project

Project Overview

This second sample project is a port expansion project, where the capacity of the existing container terminal in the port city of Karachi, Pakistan was increased. In 2005, Karachi International Container

Terminal (KICT), a member of the Hutchison Port Holdings Group, which has been enjoying the support and expertise of the world's leading port investor, developer and operator to help transform KICT into a major container handling facility that is capable of receiving the region's increasing container trade, entered into an agreement with the Karachi Port Trust (KPT) for the development of its Phase III project at West Wharf of Karachi Port (KPT, 2010).

In addition to extending the existing concession period, the project involved deepening the alongside draft to 14 meters; increasing the handling capacity by acquiring and redeveloping additional land area; and acquiring additional quayside and container yard equipment. Before the Phase III expansion, operational terminal area was 135,122 sqm, length of berths was 500 m with an annual capacity of 400,000 TEUs at an initial capital cost of US$ 65 million.

BThe purpose of the projected expansion was to increase the terminal to 260,000 sqm, berths length to 973 m and annual capacity to 700,000 TEUs with an additional investment of US$ 55 million. Additionally, the berths of the terminal were deepened to allow a 14-meter draught container ship.

Project Risks

The project underwent a variety of major, negative events/risks, namely the following: Design changes in the length of the pile driving due to the varied geotechnical conditions on site; unexpected and uneven settlement of the berth surface adjacent to the pile driving site, which rendered almost half of the old berth area unusable; and financial stress due to the 2008 credit crunch worldwide crisis with an increase in the interest rates charged by the lending institutions.

Project Mapping on the Radar Chart

The project may be plotted on the radar diagram as follows: Challenge 3, PM Responsibility 3, Focus 3 and Maturity 2. The medium-high level of challenge is due to the complex interconnection of various systems, structures and buildings devoted to different functions.

Although the project is not time critical, it possesses a medium level of innovation in building technology and process. Due to private finance and sophisticated governmental associations, the PM Responsibility is limited to the management of the budget only, where cash flow was primarily taken over by the client. The focus is on the total BOT life cycle from the initial concept design to operations. Finally, though large-sized organizations were involved, their maturity was limited to only measuring their project management processes. The project drivers are plotted on the radar diagram shown in Figure 6-3.

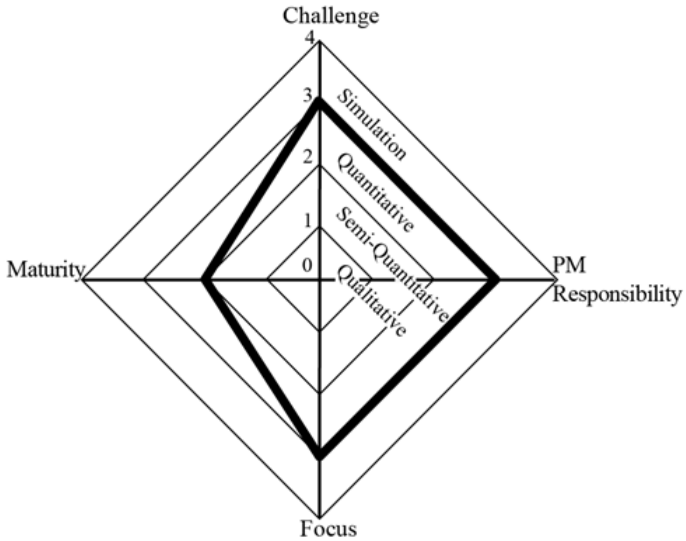

Figure 6-3: Dimensions of the Container Yard and Quay Wall expansion project on the radar diagram

The mapping of the current project is less 'unbalanced' compared with that of the previous project (Figure 6-2). The category of simulation techniques cannot be considered because there is only one driver (Focus) plotted in that region. Moreover, the categories of quantitative and semi-quantitative techniques seem a bit too simplistic given the overall complexity posed by the current project. Therefore, the natural choice would be quantitative techniques, which can be narrowed down to the "Decision Tree Analysis" technique. Due to space limitations, only the first risk ('design changes') is analyzed to demonstrate the applicability of the methodology. Additionally, established by later events, this risk proved to be extremely critical and was an enormous nuisance.

Risk Analysis

The project design team had an ambitious plan when they decided to opt for driving the steel tubular piles to support the existing quay wall to deepen the available draft. Although there was the possibility of in-situ construction, the new design was much too alluring and the associated risks were ignored. This analysis considers the possible alternatives and related probabilities.

The design could be either driving the piles or in-situ construction. Furthermore, there was considerably large probability of the piles reaching the design depth; however, in case they did not, although the probability was low, the impact was much higher in terms of monetary value, as shown in Figure 6-4. Therefore, two remedial actions could be taken: either doing the partial excavation to reach the design depth and pouring concrete to fill the gap or removing the piles and constructing the piles in-situ.

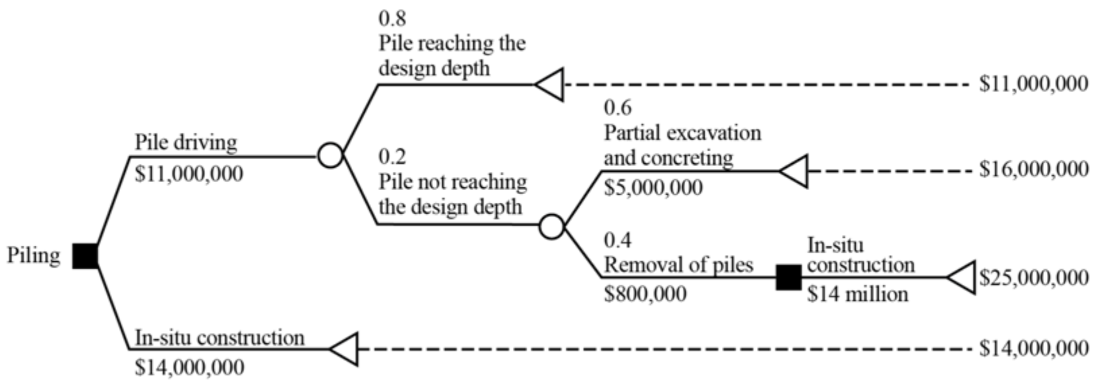

Figure 6-4: Decision tree analysis of the 'Design changes' risk in the port expansion project

Discussion

The use of quantitative techniques ensures a better and more reliable analysis in this case. Furthermore, remembering the type of risk, a decision tree analysis seems to be an appropriate choice. From the project manager's interview and other sources of information, it was found that due to geotechnical conditions, which were not properly investigated before the design, the design could not be realized and additional steps were taken that caused major delays and budget overruns in the project.

Therefore, the present scenario suggests that the category and technique selected by the radar diagram with the help of project drivers sufficiently addresses the risk analysis.

The project manager was further requested to provide a feedback of this ex-post analysis. Based on his comments, it can be confidently concluded that the accuracy and efficiency of the framework methodology left a satisfactory impression and the project manager was interested about the use of the proposed methodology.

6.6: LESSONS LEARNED AND IMPLICATIONS

With increased research and development efforts in the area of construction PRM, a larger variety of tools and techniques are made available to help perform risk management and improved performance of those tools and techniques is achieved as a result, therefore it becomes extremely important for project managers to select the appropriate tool or technique. To ascertain the suitability of the risk analysis technique, important, select drivers of the project are suggested to be used in a graphical manner. By carefully plotting and interpreting the radar chart, an advisable category of risk analysis techniques can be reached, followed by subsequently choosing a technique.

Furthermore, the use of the resulting technique will aim to sufficiently reach the required sophistication and reliability of the results. The technique will save the project managers from investing too little or too much effort and money for the risk analysis activity, ensuring a productive use of resources. It does not matter the type, size or the final budget of the construction project to create the radar diagram; the only required information is the level of its drivers-similar techniques can be obtained for projects with different budgets.

Finally, this study attempts to attract the consideration of construction management research and practitioner community to help further the applicability, suitability and affectivity of this methodology at a larger level so the testimony of consulted project managers can be justified.

6.7: SUMMARY

Complex projects require more sophisticated risk analysis techniques and vice versa: the cost and effort involved in performing expensive and labor-exhaustive analysis using simulations will benefit only when it is required, e.g., on complex, exceptional and rare projects. Simpler and routine projects may benefit from relatively simpler analysis techniques, such as qualitative techniques.

This study presents a practical methodology for helping project managers select the appropriate risk analysis technique. The methodology also broadens the perspective of the project drivers from conservative triple constraints (i.e., time, cost and quality/scope) to more extensive and realistic constraints (i.e., complexity, size, focus and maturity).

The methodology is then applied to two construction projects by creating the proposed radar diagram, obtaining the suitable category of techniques, selecting an appropriate technique from the collected depository of techniques and performing an ex-post risk analysis. The results and feedback from the associated project managers seem promising and call for more exhaustive testing at a broader level to ascertain the universality of the proposed methodology in the construction industry.

CHAPTER 7

PRM FOR BUILDING REPAIR & MAINTENANCE

Repair & maintenance (R&M) activities of buildings and structures are inescapable: aging, constant use, likely defects of design and construction, and the consequences of environmental agents and vulnerabilities cause the deterioration of building components over a period of time. R&M decisions are partly dictated by policies and regulations in the developed world, however the situation exacerbates in developing countries where large number of externalities dictates these decisions: lack of budget, enforcing regulation and building standards to name a few. Such inherent uncertainties become considerable risks and demand active management. There is a strong incentive if effective risk management is launched and established in R&M projects: better cost control, higher serviceability, lower facility down time and improved reputation along with the enhanced satisfaction on part of occupants. The need to systematically manage the risk is paramount: starting from efficient risk identification to precise analysis, and appropriate response planning to thorough monitoring and control, a tailored and specialized project risk management framework – a combination of specific tools and techniques – will greatly help by controlling risks, dealing with threats and converting them into opportunities. Conclusively, after reviewing the R&M conditions in developing countries, this chapter proposes a framework to manage R&M risk.

7.1: RATIONALE

With the knowledge of selection criteria for project risk analysis techniques, an attempt is made to propose a PRM model for building repair and maintenance projects. The rationale for this step, as a building block towards the diffusion of PRM in restoration industry, is based on the fact that building repair projects share a lot of common features with respect to restoration projects. It is not say that both types of projects are identical to each other; however there is a room for understanding the similarities and learning the lessons.

Moreover, this specialized framework is aimed at sustainability and the context of developing countries. This double-pronged strategy helps in achieving some very important milestones: it has already been established that sustainable development should be at the core of restoration of built heritage projects; therefore, precursor to PRM model for restoration projects, this proposed framework sets the stage from the sustainability point of view. Further, the limitation of developing countries provides with a non-conducive environment, increasing the complexity of the system, which offers limited space for performance and improvement. Using this limited space, the framework may emphasize the more important areas and appreciate the scarcity not only in terms of resources but also support from major stakeholders.

7.2: INTRODUCTION AND MOTIVATION

Owing to their constant exposure to the external operating environment and deterioration due to continuous use, building components are prone to ageing and wearing away which results in a decreased service life (Wall, 1993). Therefore, it is important to take corrective measures; otherwise if left to their fate, these components will eventually become inefficient, unreliable and may even fall apart, as a result, threatening the safety of very occupants they are constructed to protect. To counter the serviceability and safety challenges, building components are maintained in such a way that they continue to perform their designated function. The maintenance and refurbishment techniques may vary depending upon the context, magnitude and scope of work; however more modern and sophisticated methodologies and principles are advocated to manage these activities (Bryde and Schulmeister, 2012).

The British Standard 3811:1984 describes *'maintenance'* as the intricate combination of technical and associated managerial actions which are aimed at retaining a building component in (or restoring to) a state in which it can perform its required function (Seeley, 2003). According to Chanter and Swallow (2008), and Wordsworth and Lee (2001), the apparent objectives behind any maintenance operation are:

- To ensure the safety of the buildings, their components and their associated services.
- To ensure the usability of the buildings and their components.
- To ensure satisfaction and fulfilment of all the necessary statutory requirements.
- To execute work necessary to maintain the quality and serviceability of the buildings.

The maintenance activities, irrespective of being 'preventive' or 'corrective' in their nature, must be treated as a project. Hence, the actions and objectives mentioned before are those associated with conception, planning, execution and close out – a typical project lifecycle.

In his seminal work, Wall (1993) has identified five technical and managerial matters (the effect of climate, design and material choice, construction and maintenance personnel, managerial systems and financial system) which are at the core of renovation and maintenance causes and decisions. The work is all the more important owing to its focus on economic prospect (affecting the sustainable results eventually) and context specificity with developing countries, where these matters are even more exacerbated due to encompassing at least six forms of capital: human, natural, cultural, institutional, physical and financial.

In contemporary times, the notion of *'sustainability'* seems to dominate the debate; owing to quickly withering environmental conditions and ailments, the idea of *'sustainable development'* has emerged as an effective response (Hill and Bowen, 1997). Sustainability (commonly defined as a complex – and often contradicting – interplay between economy, society and environment), in the context of built environment, is vital since the building activities have always had significant and sometimes unaccounted for consequences; globally, over 35% of industrial waste is contributed by these activities (Construction Materials Recycling Association, 2005; Hendriks and Pietersen, 2000): in Hong Kong alone this percentage is more than 38% (Hong Kong Government – Environmental Protection Department, 2006)). Housing is another important factor, profoundly contributing in the environmental footprint of building activities (Ofori, 2007). Thus, the environmental impact of construction activities is enormous which warrants for linking and dynamically managing it with environmental management systems and green procurement (Varnäs et al., 2009).

The maintenance activities, where huge piles of waste are generated, are no less challenging and hazardous when it comes to threatening the sustainability and harming the environment. To curb this menace, a number of studies have taken place (Furcas and Balletto, 2012; Yuan, 2011; Solís-Guzmán et al., 2009; Kourmpanis et al., 2008; Chung and Lo, 2003; Fatta et al., 2003) and developed nations have come up with strong regulations (Nitivattananon and Borongan, 2007; Cheremisinoff, 2003; Kreith, 1995) to ascertain and control the impact of renovation and maintenance works on sustainability objectives.

The state of affairs (regarding the productivity and profitability) in construction industry of developing countries is impaired: from lower efficiency to shabby reputation, from frequent delays to quality compromises, the construction industry is marred with a lot of criticism (Zou, 2006). Not only the situation is alarming for the clients, occupants and users, but the parties involved in execution are equally at risk (Enshassi et al., 2006). In their seminal work on the plight of construction industry development in developing countries, Ofori and Toor (2012) have traced the footsteps of some of the simmering problems which are at the base of construction industry's predicament. In short, the construction industry in the developing countries lacks the sort of maturity as deservingly boasted by that of industrially advanced countries (Willis and Rankin, 2010).

However, some influential work is done to not only introduce the notion of sustainable construction in developing countries but also to advocate its efficacy with the help of easily implementable agenda. In her pivotal and inspiring work, responding to the urgency of making sustainable intervention during the construction of built environment, Du Plessis (2007) proposes a strategic framework which, in an attempt to capitalizing on the opportunity of avoiding the problems already experienced in developed countries, focuses on ascertaining smart usage of scarce resources by ensuring the sustainability of currently constructed built environment. The framework traces a trio of enablers (technology enablers, institutional enablers and value system enablers) which are at the core of successful integration of sustainable construction in developing countries.

On the other hand, aggravating the situation in the context of developing countries is not-so-promising *‘attention to detail’* tendency for sustainable development, which is clearly unsettling: restricted by weak and exhausted economies, vulnerable social conditions and insubstantial appeal to environmental concerns, developing countries risk bearing greater losses trying to avoid smaller ones (e.g. not performing routine maintenance operations and eventually facing serviceability problems). Correspondingly, proper and timely maintenance helps achieving longer economic life, resulting in lower depreciation costs and thus higher profitability. Although international efforts of venturing into sustainable development in these developing countries may seem promising, they are still far away from achieving justifiably *green* results without streamlining practically every aspect of sustainability.

Building repair & maintenance (R&M) decisions are critical in their nature owing to above mentioned facts. Also, based on evident reasons (Myeda et al., 2011; Amusan, 2011; Ali, 2009), the humble track record of developing countries in achieving sustainability in R&M actions is further complicated due to project externalities: lack of budget and enforcing regulation for example. One of the important reasons is the inconsistency of planning and development policies; mainly influenced and manipulated by the short-term political goals, rise in housing demand due to increasing urbanization and near-constant upheaval in economic conditions, developing countries witness speedy and hasty construction with lower level of planning and management precision, which eventually result in higher R&M operations (Du Plessis, 2007). Inefficient and unproductive use of construction material, at the beginning, later triggers wasteful R&M actions: environment and economy suffer from constant construction and reconstruction and the money overspent, which could otherwise be used for social causes, harms the sustainability. This becomes a vicious cycle of overspending and harming the environment. Therefore effort must be exerted to manage the risk posed by R&M operations. Starting from efficient and reliable identification to seamless analysis, and suitable response planning to detailed monitoring and control, attempts must be made to understand how risky these undertakings are and how to deal with apparent threats for successfully converting them in opportunities.

Since R&M projects have high impact in the realm of sustainability, it is opportune and justified to have a modified, specialized, systematic and formal PRM framework to accommodate the specific needs. However, the common practices do not seem to consider the R&M activities as full-fledged projects and advocate their risk management using customized approach. Also the literature seems lacking of such a methodical attitude and the diffusion of risk management techniques and standardized practices compared to other fields and industries. However these projects are vital concern for undertaking organizations and occupants as, if not managed correctly, the risk faced by the projects may not only cause failures (Krane et al., 2010) but also harm the notion of sustainability and serviceability. Taking on the motivation and research impetus from Wang et al. (2004), it can be deduced that there is a strong case for disseminating the knowledge of project risk management (PRM) (and its effectiveness) in R&M sector and to learn the lessons from construction industry since both share common features.

However, it can be argued that logic for such a specialized framework is not well-grounded (and unsuitable, as a result) owning to the fact that R&M projects are considered small routine activities with fewer complexities. In response to that, the author reckons that defying the market logic, which warrants for equal (if not more) return on investment, is not the aim of this proposal. On the other hand, curbing the frequency of such projects is more of the focus in the realm of small routine projects. The constant wear and tear, if not attributed to the extraordinary outdoor and occupancy conditions, hints towards lack of understanding of the ecosystem and modern materials among the multitude of other reasons. These details constitute the fundamental understanding of risk in such projects and the aim of this proposal is to be well-suited in the variety of R&M projects ranging from larger and more serious undertakings to the smaller and routine activities.

7.3: RISK MANAGEMENT PROCESS

The risk management process is a systematic and well-structured way of managing risky situations in a project. In the context of a project, risk management turns into more specific set of guidelines termed as project risk management (PRM). PMI defines PRM as a subset of project management with four integral processes: risk identification, risk analysis, risk response development, and risk monitoring and control (PMI, 2009). To core idea behind this process is to take necessary actions in order to assess and pre-empt potential sources of risk (Berkeley et al., 1991).

Risk identification is the initiation activity of a standard PRM process which entails identifying risks prior to managing them. Identification points out risks and threats before they become problems, and adversely upset a project (Carr et al., 1993). What cannot be identified, cannot be managed; hence the rationale for risk identification. There are a number of techniques, different in nature and functionality, which assist in identifying potential risk. However, this proposal mostly relies on interviewing and brainstorming; later being a combinatorial technique for identifying as well as analyzing risks, whenever required (del Caño and de la Cruz, 2002). Delphi technique may also be suggested which, though a little more laborious, has the advantage over brainstorming in a number of ways. The motivation comes from the fact that these techniques are highly efficient in situations where established taxonomies are either scarce or do not exist.

Successful identification prepares ground for risk analysis. It is important to understand that apparent constraints on the resources may never allow managing all the possible risks in any activity, therefore it is important to prioritize them. Risk analysis is the process of prioritizing the identified risks based on qualitative and quantitative assessment by investigating their probability of occurrence and resulting impact. In order to simplify the task, qualitative and semi-quantitative techniques are widely used (PMI, 2008). Qualitative techniques do not operate on numerical data but present results in the form of descriptions. The risk is evaluated in more conceptual terms, such as high, medium or low, regarding collected opinion and risk tolerance boundaries in the organization. The purpose of qualitative risk assessment is to determine the degree of the probability and impact of risk in characteristic form. Examples of qualitative techniques are brainstorming, cause and effect diagram, checklists, Delphi, event tree analysis, etc. (Hubbard and Evans, 2010). On the other hand, semi-quantitative techniques, which are basically a derivative group, associate a scale factor to nonnumeric ranking. For example, a score of 1 to 5 can be assigned for ranking risk factors affecting the project performance. Likert scale is a well-disseminated example of this kind of analysis. Some other examples are interviewing, probability and impact matrix, risk probability and impact assessment, etc. (Baccarini and Archer, 2001).

As a result of analysis, ranking of risk is attained and based on the tolerance level and criticality indices, a cut-off point is set. Risk items falling under the purview of this exclusion are further managed by developing respective responses for them; it is the process of exploiting options and decisions for increasing the positivity and decreasing the negativity. Finally, the lifecycle process of monitoring and control takes place, which supervises the implementation of risk responses, identifies any new risk and brings them in the risk management process, and evaluates the overall effectiveness of the entire process (Chapman, 1991).

7.4: PROPOSAL OF PRM FRAMEWORK FOR R&M PROJECTS

Based on the above mentioned motivation and rationale, and the reviewed standard PRM process, a specialized PRM framework is proposed in the following section which is aimed specifically at the R&M

projects and attempts at capturing the intricacies of these undertakings along with possible opportunity-ceasing prospects. The anticipated contribution of proposed framework is limited to risk assessment (combination of identification and analysis of risk); beyond that, it does not offer the preventive or mitigating measures for handling such events owing to the fact that at such situation, every risk needs specific technical treatment, which is beyond the scope of this research.

7.4.1: Context of the framework

The proposed framework offers a practical and convenient methodology to implement the PRM in the R&M projects. Based on the work of De Marco et al. (2012) and De Marco and Thaheem (2014), and found on the knowledge of maintenance project drivers and general industry context, the framework recommends convenient and easy-to-use risk analysis techniques, such as qualitative and semi-quantitative. Undoubtedly, there is an apparent trade-off between convenience and precision; however, in order to introduce the notion of risk management in R&M projects, the author considers it worth opting for. The more sophisticated (and to a certain degree demanding in terms of their input parameters) techniques, such as quantitative or simulation-based, may later be proposed based on the industry's response to inculcating the PRM culture and equipping itself for the complexity and requirements of higher expertise required for such techniques.

7.4.2: Risk identification techniques

In order to find risk events, the proposed framework suggests the use of interviewing, brainstorming and documentation review (PMI, 2009). The rationale behind interviewing is driven by the apparent value offered by personal-contact in the form of specified and focused data gathering. In situations where it is not easy to find risk taxonomies and checklists easily, interviewing by human interaction can by helpful in gathering important information.

Multidisciplinary interview sessions are proposed involving experts with prior background in R&M projects. The diverse team of participants may ascertain the identification of risk events pertaining to a broad spectrum, such as construction, materials, commerce, sustainability, etc. Further, to ensure more in-depth and holistic information gathering, semi-structured and non-structured interviews are suggested.

Brainstorming is also proposed as a potential identification and ranking technique. It can have two prong uses: it may help finding out more risk, which may have been overlooked during personal interviews and afterwards rank them narrowing down the identified risks, thus it helps in refining the overall process.

Wherever possible, the risk identification phase may also benefit from reviewing previous documents. Documentation reviews involve reviewing as-built drawings, maintenance plans, detailed specifications, assumptions, historical information from a total project perspective as well as at the individual deliverable- or activity-level. This review may help the stakeholders identify risks associated with the objectives set out in the first place.

7.4.3: Risk analysis techniques

The proposed framework, as deliberated initially, constraints the risk analysis part within the qualitative and semi-quantitative techniques for the sake of convenience. It suggests using risk probability and impact assessment, which is a twofold analysis technique: risk probability assessment explores the probability of occurrence of risk and impact assessment examines the resulting effect on project objectives should the risk occur. This assessment can be performed by individual interviewing (high bias chances) or brainstorming (low bias chances). The participants pertaining to various expert areas of R&M and sustainable development nominate probability and impact of risks and later rank the risks in the order of their significance.

For semi-quantitative analysis, the framework proposes the use of probability and impact matrix. A likert scale, from 1 to 5, is advised for determining the subjective probabilities and resulting impacts for each identified risk from the experts. The suggested probability and impact scales are: 1 – Very Low, 2 – Low, 3 – Medium, 4 – High and 5 – Very High. The numerical parameters are then put into the matrix (Probability and Impact Matrix by PMI (PMI, 2009)) to find out the risk ranks in terms of their significance, such as High, Medium and Low.

7.4.4: Project Management process

R&M projects involve a multitude of competencies and need a team composed of, but not limited to, architects, engineers, technicians, managers, sustainability experts, environmentalists etc. Managing such diverse teams may prove to be extremely challenging. Therefore, it can be conclusively established that the management of R&M projects stipulates for specialized and customized PM process. Inspired from the work of Amusan (2011) and Croci (2000), a detailed lifecycle of R&M projects is proposed, as illustrated in Figure 7-1.

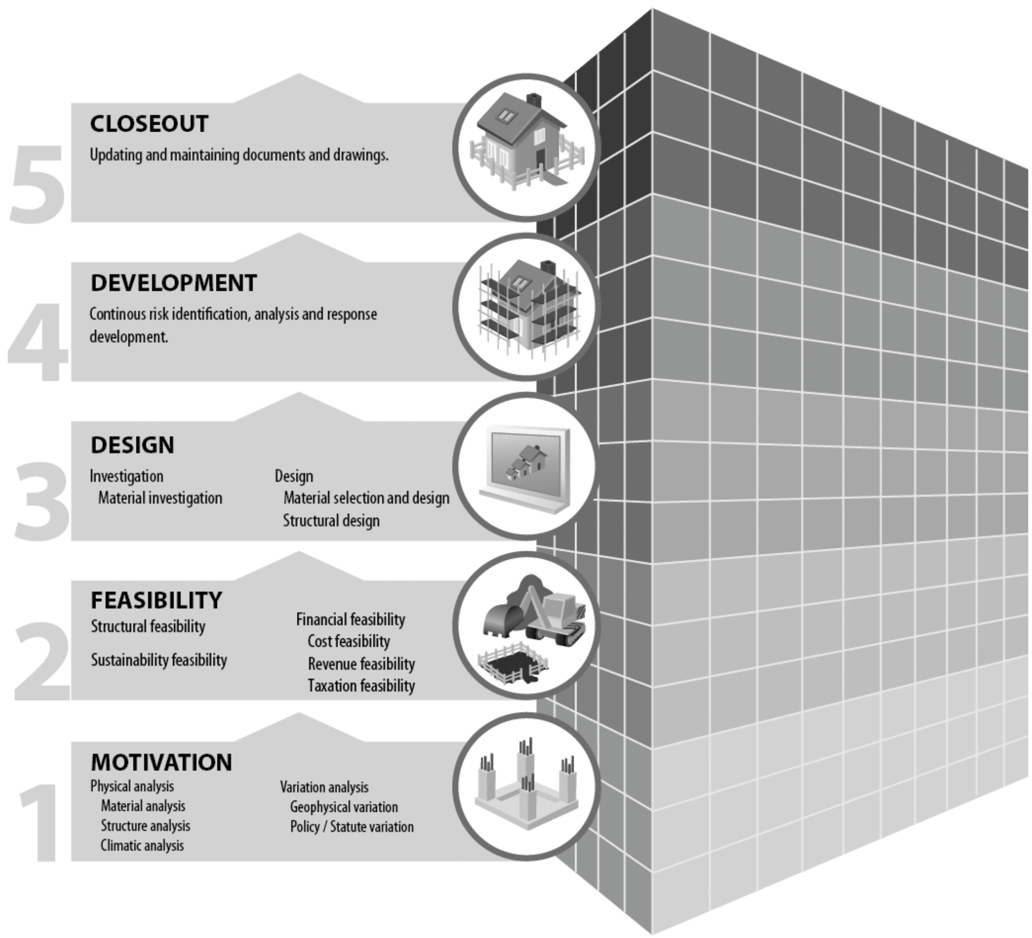

Figure 7-1: Proposed PM process for R&M projects

Motivation/Need for R&M

The process starts with establishing the motivation and the need for repair and maintenance. It is definitely the most important element of the entire PM cycle. In the first phase, the physical analysis (synonymous to *'damage analysis'*) is carried out which involves thorough inspections. The material and structure are examined for damages and decay, and the need to repair is realized as it is always significantly cheaper than replacement. It is essential to fully understand the physical damage (and its degree) before making any R&M decisions. Further a climatic analysis is carried out since it is very essential to consider the atmospheric conditions of the surroundings of the building because determining the kind of climate the building interacts with, it will be easier to take critical decisions regarding material selection. It is essential to reassert the importance of material selection at this juncture because the usage of improper and unfitting material is at the core of higher frequency of maintenance and reduced service life.

Afterwards, an analysis of variation is carried out where changes in geophysical and political/statutory conditions are examined. The upgraded hazard maps show increasing seismic risk in previously undocumented zones of the world which clearly indicates a variation in geophysical conditions resulting in seismic retrofitting as critical R&M action. Also the changing environmental and atmospheric conditions pose risks of their own kind, thus the maintenance is sometimes only motivated due to exogenous changes.

Corresponding to this phase of PM and with standard PRM process, the framework suggesting carrying out risk identification due to its importance as it will expose most of the threats and opportunities the project will be subjected to. There is a wide array of techniques suggested at this stage: ranging from visual inspection to interviewing the specialists, reviewing old documents and as-built drawings to brainstorming amongst the experts, this initial stage demands for rigorous usage of tools and techniques for effective and holistic risk identification. At the end of this phase, the project stakeholders may obtain a checklist of risks which may also be arranged into a taxonomy for future use. It is pertinent to mention here that the surveyed distance between academic and industrial versions of risk taxonomies is alarming in the field of construction (Barlish et al., 2013). Therefore an industry-driven initiative to form taxonomy for R&M risk will hold more ground and relevance for future projects of similar nature.

Feasibility

The second phase of process deals with the feasibility study which aims at establishing the viability of maintenance viewed from different perspectives. The present level of structural integrity and its capacity to undergo a *'therapeutic'* procedure must be determined. Therefore, it is opportune to carry out the structural feasibility of building before making any restoration decisions. This may involve NDT investigation over various structural and non-structural building components. Further, feasibility of maintenance in terms of repair/renovate/replace/refurbish is done with chief importance to the sustainability. In case of developed countries, where there are higher landfill taxes, there may be some incentive to repair and reuse but same can only be justified in developing countries based on replacement cost. Lastly, the financial feasibility, in terms of cost, revenues and taxes, must also be established and transformed into a Cost Management Plan (PMI, 2009). Since the serviceability of buildings is extended as a result of active R&M, the new depreciation accrued must be taken into account. In case of public buildings, the serviceability is further affected by the use-value.

At the end of the feasibility phase, a conclusive decision may be made in favor of R&M project or vice versa. The PRM proposal for this phase stresses for further risk identification. Apart from interviewing, it is also advisable to perform brainstorming by bringing on-board experts from various disciplines, such as architecture, engineering, building, economics, environmental engineering, and project management. Also financial, structural and historic documents must be reviewed to countercheck, validate and strengthen risk identification. At the end of this phase, the project stakeholders may revise the taxonomy by updating newly identified risks.

Design Phase

Following the successful feasibility phase, a design of maintenance is planned in terms of materials, structure and other PM variables (cost, time, quality). The previously used materials may not be available in some cases due to a number of reasons. Therefore, it is important to first investigate for available ones which not only possess similar characteristics, but are also capable of facing modern challenges and are environmentally sustainable. Thus, a design phase is carried out where the suitable R&M materials are either selected from a range of available ones or designed on-demand, followed by structural design necessary for the intervention. It is important to design and guarantee the structural reliability of the building in the face of new material, possible additional fixtures and loads, and modern protecting techniques, such as retrofitting. Also, the standards and regulation pertaining to sustainable development must be considered on priority to ensure not only economic gains but also the environmental and social impacts.

During this phase, the PRM includes identification of risks introduced due to design, followed by their analysis. For qualitative analysis, risk probability and impact assessment must be performed and risks be ranked according to their importance. For semi-quantitative analysis, probability and impact assessment must be performed where, based on the expert judgment and physical data, relative probabilities and resulting impacts are allotted to these risk items. Since all the identified risks can never be managed due to limited resources, only the most significant and threatening risks are responded to. So, the analyzed and ranked risks are further filtered, based on a brainstorming, for selection of most significant ones for which the effective responses are developed.

Development

After the design, the R&M works are executed which involve onsite physical activities employing construction and restoration workers, and engineers. The building is more susceptible and at risk during this phase than at any other time due to exposure to external environment, health and safety concerns to occupants or passersby, etc. Therefore, the project and site managers must be required to look for any new risks evolving due to the on-going site work. Especially during the phases of deconstruction and dismantlement, it is important to hunt for the areas of concern; identify risky situations, analyze them and quickly come up with some practical response. Risk identification by visual analysis and interviewing the site staff is advisable. For risk analysis, semi-quantitative techniques are suggested, which will help in further proposing the corrective measures. Also, the notion of occupational health and safety must be deliberated and appropriate measures must be taken to ensure secure and protected site by providing necessary PPE (personal protective equipment) to site staff.

Closeout

After the successful development of the project, it is closed out. Starting with a detailed intervention report, it is advised to document the entire PRM process in this phase, mentioning the risks identified, threats faced and opportunities exploited along with their probability of occurrence and impact of consequence. Also, the corresponding preventive and mitigating measures must be documented. Together with that, other important project documents are suggested to be prepared. Moreover, the layout and as-restored drawings should be prepared to be made part of the record, which may be referred to and reviewed at a later stage or for the next maintenance.

7.5: CONCLUSION

Repair and maintenance works are creating nuisance for sustainability and, apart from a myriad of internal and external drivers, *'waste regulation'* is dictating R&M decisions, which are not aptly streamlined with the established PRM framework. The story is even more aggravated in case of developing countries where environmental concerns are further burdened by weak economies, and indifferent and dispassionate societies. Even the governance of construction (and restoration) activities in the developing countries is incapacitated (Lizarralde et al., 2013). The local culture does not seem to value the environment enough to advocate and effort for proactive (or even the reactive) measures. An overly laid-back attitude is displayed towards environmental concerns and sustainability seems to be taken for granted possibly due to lack of awareness and understanding of importance attributed to these naturally (and freely) available resources. This, however, poses greater need to streamline sustainability concern into active project management and project risk management practices by advocating for, promoting and offering customized frameworks and tools. This chapter proposes a theoretical framework customized to manage the R&M projects and deal with their risks in a sustainable manner. The framework is further tweaked keeping in account the conditions and challenges of developing countries where priorities can be drastically diverse and focus can be short sighted, where the expertise is mostly reserved for more complex and financially-stringent activities and where the ascertaining precision seems quite challenging.

For improving the efficiency of R&M projects and ensuring the sustainable development, the proposed framework seems promising for achieving the objectives in a systematic manner. Further, the proposed techniques will ensure required level of details for risk identification, analysis and response development.

Based on the novelty of PM and PRM areas of knowledge for the R&M context, the framework has been restricted to convenient tools and techniques due to inadequate maturity of the industry. In order to improve the efficiency of the current framework, more sophisticated tools and techniques are planned to be included at later stages strongly based on acceptance and positive feedback from practitioners.

CHAPTER 8

PRM FOR SUSTAINABLE RESTORATION OF IMMOVABLE AND BUILT CULTURAL HERITAGE

Restoration of cultural heritage buildings, in the face of ever-uncertain and risky future, has become a worldwide trend due to the emphasis on its benefits concerning architectural, economic, social, political and spiritual values (Garrod et al, 1996; Feilden, 1994). Its goal is to provide the correct maintenance of cultural heritage in order to enrich the future (Pinheiro and Macedo, 2009).

Disasters – of natural and artificial nature – are the core concerns for conservation experts. The literature is jam-packed with knowledge areas of *'disaster risk management'* (Kobe Report, 2005; Peek and Mileti, 2002) and *'preservation risk management'* (Waller and Michalski, 2004; Ashworth, 2001; Caple, 2000; Weller, 1994). These disasters pose ever-growing threat to the integrity and safety of heritage buildings. Though it is beyond the scope of this research to argue over the need to restore such buildings, it will be sufficient to mention that these buildings represent history, community and national values and above all a sense of identity (Wangkeo, 2003). International giants, such as ICCROM and ICOMOS, have done a lot of work on the risk preparedness and prevention strategies to cope up with these disasters and as a result, international conventions have been formulated. Also recommendations have been published for analysis, conservation and structural restoration of cultural heritage. However conclusive evidence suggests that sometimes these calamities get the better of human effort and end up with disastrous aftermath (Taboroff, 2000).

Restoration, preventive or corrective, is carried out in order to reinstate the historic building in as much its original shape as possible. Before moving any further and without taking sides of the argument that is built around the debate of *'originality'* in the realm of architectural heritage (Larkham, 1996), it is opportune to explicate that proposed definition of restoration mainly aims at reconditioning the artifact in its architectural originality. That is to say that a holistic approach is not only suggested and advocated here but measures are taken to ensure it is somehow realized.

In view of that, the restoration activity is a custom-built undertaking for every heritage artifact based on their variety and nature. Generic guidelines are available but fitting with specific conditions, tailor-made actions are inevitable, giving raise to adhocism. As a result, there is always a tremendous amount of uncertainty involved in these projects. Therefore, restoration projects are largely affected by risks. Moreover, these projects do not seem to take holistic view of the structure's lifecycle and therefore are subject to changing environmental conditions. This definitely has implications on the sustainable development aspect as well; in other sectors, the life-cycle thinking tools have been successfully utilized to ensure project sustainability (McConville and Mihelcic, 2007).

Historic buildings are more vulnerable during building works than at any other time in their lifecycle. Apart from the maintenance of originality, some other most important risks are the lack of availability and knowledge of historical material, uncertainty of construction techniques employed, and the availability and capacity of specialized workforce (Grama et al, 2011; Wang et al, 2008; Croci, 2000).

Therefore, the intricate nature of restoration projects and the involved risks demand for a systematic and formal PM and PRM approaches respectively. It also demands to clearly and distinctively address the assessments of risk and impact: the former involving exposure to danger (or wellbeing), whereas the later referring to occurrence of risk. In his influential work, Bellance (2011) argues for and attempts to establish a methodical approach towards the restoration of historic architecture, yet the need and incentive for incorporating management approaches to restoration seem overlooked. The literature in general seems lacking of a methodical attitude, and the diffusion of risk management techniques and standardized practices compared to other fields and industries. Nevertheless, it is believed that there is enough rationale to advocate for this methodical attitude towards restoration by integrating the theories, practices, tools and techniques of PM and PRM. In addition, the gap does not appear to be limited to the literature only, but it seems deep rooted in the culture of restoration projects. Ideally, these processes must be vital and momentous concern as, if not managed, risk may cause project failures (Krane et al, 2010). Taking on the motivation, it can be deduced that there is the need to disseminate the knowledge of PM and PRM (and their affectivity) in restoration sector, and learn the lessons from construction industry as both share some common features. However, the former still demonstrates different dynamics and challenges, and demands for corresponding responses.

The construction industry is characterized by carrying out green field building activities using the prevailing materials and techniques, whereas the restoration industry deals with the existing entities made up of ancient and oftentimes outdated materials posing risks of their own kind (Pinheiro and Macedo, 2009; Cultural Heritage Bureau, 2005). Also in the realm of construction industry, there is evidence of the Life Cycle Thinking approach (Olander, 2012; Kohler and Moffatt, 2003) which seems ignored for restoration projects. In the absence of this kind of approach, restoration projects may not successfully imbibe and respond to the uncertainties; precisely, they are not seen as futuristic in their approach. However, the LCC (lifecycle costing) approach is still not properly integrated into the construction projects, which is essential for environmental decision-making (Gluch and Baumann, 2004).

The ages-old construction techniques which were employed for them are also not necessarily well documented and preserved. The as-built drawings and specifications are usually non-existent. In the midst of this uncertainty, the restoration projects are aimed at maintaining the originality and ensuring that the restoration 'therapy' will respect the subject (building/monument/structure) and its fragility. If managed scientifically, these risks along with their affect can be minimized, potential opportunities can be exploited and project objectives, in terms of schedule, budget, quality, scope, originality, safety, sustainability, etc., can be affectively achieved.

Looking at the available literature, industry practices and the gravity posed by the reported risks, it is imperative to have a formal and specialized PRM process for restoration projects which possibly takes into account the entire lifecycle approach. However, it is still not practically introduced and employed due to apparent lack of motivation towards PM in the restoration industry. Of the few available material, ICOMOS (ICOMOS, 2003) has somehow pioneered the concept of risk in restoration and rehabilitation projects. Another notable *'intergovernmental organization dedicated to the preservation of cultural heritage worldwide through training, information, research, cooperation and advocacy programs'* (ICCROM, 2013) has also been striving to incorporate the risk management knowledge in cultural heritage (ICCROM, 2009). It is important to note here that general scope of projects is time bound; that is a project has a fixed beginning and end. On the other hand, the Life Cycle Thinking is a kind of approach which may be better integrated into operations management.

To this end, this chapter introduces the concept of PRM in restoration projects, proposes a practical framework consisting of PM process and parallel PRM actions, and takes it one step ahead by motivating the industry to actually implement it. Although equally applicable to other cultural heritage artifacts, the framework has mainly been thought around the heritage buildings (including monuments, castles, churches/mosques/religious places, etc.). In the next chapter, the proposed framework is ex-post applied on a few restoration projects and critical findings are gathered and discussed.

8.1: BACKGROUND

Cultural heritage is broadly defined as consisting of movable and immovable, tangible and intangible heritage with strong historic, artistic, scientific, social, economic and cultural values of identity (Kobe Report, 2005; UNESCO, 2005). Goods of cultural heritage include monuments, buildings, historic ensembles, works of art, crafts, documents, literary works, ethnological treasures, archeological remains, and even the intangible attributes such as oral traditions, unwritten languages and folklore (Bedate et al, 2004) which are of "exceptional universal value from the point of view of history, art or science" (Veco, 2010). Cultural heritage is important for the pride of host nation and community, and their internal cohesion (Bedate et al, 2004). It has been gaining momentum at the global, national, and local levels due to major significance towards sustainable development and its components of environmental protection, and socioeconomic development (Kobe Report, 2005). The increasing emphasis over sustainable development is more relevant in the context of cultural heritage as it is one of the few areas which have an effect upon all three pillars of sustainability: economy is associated with the commercial nature of these artifacts; society is at the core of cultural heritage as it represents historic and social affiliations; and environment (in terms of environmental changes and challenges) has a direct impact on these artifacts due to their old age and inherent fragility.

Although the value and authenticity of cultural heritage is hard to be assessed by fixed criteria (Bedate et al, 2004; ICOMOS, 2003), attempts are still made to comprehend its cultural significance (Sanz et al, 2003; Mason, 2002). The reason behind this laborious pursuit is the fact that cultural and historic values strongly shape the conservation (and restoration) decisions (ICOMOS, 2003) along with other economic, commercial, environmental and national/regional drivers.

Owing to their age, location and previous maintenance, cultural heritage buildings are vulnerable to a number of hazards, rare and catastrophic, and continual and slowly damaging, originating from diverse material composition and geographical spread of heritage structures (Brokerhof et al, 2007). In order to respond to these threats, restoration is carried out which is the methodological moment when the building is appreciated in its original material/structural form, and in its historical, social and aesthetic triality with a goal to pass it on to the future generations (Brandi, 1977). It is opportune to realize and appreciate the exceeding complexity of restoration decisions: the effect of an erroneous choice may cost dearly to the building, society and economy, thus posing a threat to the sustainability. Hence, in retrospect, the resolve to restore is a tricky undertaking in itself which needs some serious *'impact assessment'* (IA). IA is the process of structuring and supporting restoration policies, which are then translated to individual projects. It defines and assesses the risks and hindrances at hand, and the projected goals. It classifies the major choices for achieving the goals and analyses their expected impacts in the economic, environmental, social, historical and structural/engineering fields. It sketches the costs and benefits, advantages and disadvantages, and cultural implications of each choice and investigates into the possible synergies and trade-offs (European Commission, 2013). Risk assessment, being a phase of risk management, forms part of impact assessment as the risks are identified and measured (qualitatively or quantitatively) during this process. The risk assessment output acts as critical input to restoration decision making. Formalizing further, it is preferred that risk management is supported by heritage impact assessments (HIA) and environment impact assessment (EIA) (Roders and van Oers, 2012). Though restoration does not entail new development, it nevertheless involves site operations which might cause harm to heritage artifact under restoration or others nearby. Incorporating HIA and EIA as predecessor to PRM will greatly help in ensuring that the restoration works will be in harmony with the existing cultural ecosystem.

Restoration projects face a number of risks. 'Risk' is defined in the context of PM as an uncertain event whose occurrence may have a negative or positive effect on the project objectives (Raftery, 1994; Chapman, 1991). For a restoration undertaking, the project objectives may be reinstatement of the originality of the historic building keeping in view the safety of structure, users of the place and sustainability concerns.

Further, according to ISO 8402:1995/BS 4778, risk is a combination of likelihood (probability) for a certain problem to occur with the corresponding value (impact) of the damage caused. It is the occurrence of a negative event or the non-occurrence of a positive event. In the restoration literature, the risk taxonomies, which can normally be found in other engineering fields, are missing. Taxonomy is a breakdown of possible risk sources and is considered to be a prime tool for identification. In any case, some of the reported risks are the availability of knowledge of material, construction techniques and specialized workforce, the changing underground conditions and structural dynamics, changing national and international regulations, damage to structural integrity, availability of information on previous interventions, innovation in technology, concealed and hidden uncertainties, etc. (Grama et al, 2011; Wang et al, 2008; Croci, 2000). A formal PRM process, described in next section, is at the core of addressing risks in restoration projects.

8.2: PROPOSAL OF PRM FRAMEWORK FOR RESTORATION PROJECTS

8.2.1: Context of the framework

The proposed framework provides a practical and convenient methodology to implement the PRM in restoration projects. It mainly deals with the risk assessment (combination of identification and analysis of risk). Based on the work of De Marco et al (2012), which is further refined in De Marco and Thaheem (2013), and found on the knowledge of restoration project drivers and restoration industry, the framework recommends more convenient techniques, such as qualitative and semi-quantitative, to suffice for the purpose of risk analysis. The more sophisticated and demanding (in terms of their input parameters) techniques, such as quantitative or simulation-based, may later be proposed once the restoration industry inculcates the project management culture and equips itself for the complexity and requirements of higher expertise essential for sophisticated techniques. Nevertheless, these techniques may be applied for large and complex restoration works.

8.2.2: Proposal of risk identification techniques

For identifying risks, the proposed framework suggests the use of interviewing, brainstorming, Delphi technique, documentation review and SWOT analysis (PMI, 2009). Also, the proposal suggests use of visual and structural risk identification techniques. The motivation for interviewing is based upon the significant affectivity offered in the form of personalized and focused data gathering. In a state where the restoration industry lacks a sizeable amount of risk taxonomies and checklists, interviewing, human interaction and investigation can efficiently help in gathering unstated and inferred knowledge on restoration risks.

Multidisciplinary interview sessions can be organized involving experts with prior background in restoration projects. The diverse team of participants may ascertain the identification of risk events pertaining to a broad spectrum. From semi-structured to non-structured interviews are suggested in order to ensure more in-depth and holistic risk identification, and to avoid the selective information gathering based on selective exposure theory (Sears and Freedman, 1967).

Brainstorming is also proposed as a potential identification and ranking technique. In the phase of risk identification, brainstorming can be utilized for narrowing down the identified risks, thus refining the overall process. Though there may not be a fix number of participants for brainstorming sessions, it is adequate to state that fair amount of representation from all the possible stakeholders must be ensured; otherwise chances are the decisions may bend in some particular direction (conforming to powerful individuals/groups) which will impair the objectivity of the process. Further, in order to get rid of Groupthink and social conformity, Delphi technique is also proposed for the phase of risk identification.

Wherever possible, the risk identification phase may also benefit from reviewing previous documents. Documentation reviews involve reviewing restoration plans, detailed specifications, assumptions, historical information from a total project perspective as well as at the individual deliverables or activities level. This review may help the stakeholders identify risks associated with the objectives set out in the first place.

Though not covered in the existing formal body of knowledge on PM and PRM, the proposal advises use of visual and structural risk identification techniques. Experts may be asked to perform the field work and visit the building and nearby areas to formulate a visual log of risks involved (The Project Management Monkey, 2009). The structural risk identification involves the use of non-invasive and nondestructive testing (NDT) techniques in which the unexposed structural and geotechnical features are uncovered and pertinent risks are logged for further analysis. The expertise required for this type of identification ranges from technical to mechanical and all the way to architectural.

Finally, the proposed framework advises to perform SWOT analysis based on the information collected from interviewing and brainstorming. This analysis helps broaden stakeholders' perspective of where to look for risks and how to manage them.

8.2.3: Proposal of risk analysis techniques

For analyzing risks, the proposed framework implies the use of qualitative and semi-quantitative techniques.

The proposed qualitative techniques are brainstorming and risk probability and impact assessment. Brainstorming is a combinatorial technique for risk identification and analysis (in the form of risk ranking), and can be used to categorize risks based on their general characteristics of probability and impact. The participants, pertaining to various expert areas of restoration, rank the risks in the order of their significance under the leadership of a facilitator. The analysis can be further narrowed to investigating the corresponding probabilities and resulting impacts, as reported by the participants. Risk probability and impact assessment is qualitative analysis tool where probability and impact of risk items are qualitatively measured (such as very high, high, moderate, low and very low) and further evaluated based on their resulting impact on project objectives (PMI, 2009).

For semi-quantitative analysis, the framework proposes the use of probability and impact matrix. A Likert scale, from 1 to 5, is advised for determining the subjective probabilities and resulting impacts for each identified risk from the experts. The suggested probability and impact scales are 1 – Very Low, 2 – Low, 3 – Medium, 4 – High and 5 – Very High. The numerical parameters are then put into the matrix (Probability and Impact Matrix by PMI (PMI, 2009)) to find out the risk ranks in terms of their significance, such as High, Medium and Low.

Once the risks have been ranked, the managerial decision can be taken as to which category (s) of risks will be actively responded to. The purpose of responding and treating risks is to minimize or eliminate the potential impact they may pose to the achievement of set objectives. Usually this kind of decision is driven by multiple criteria ranging from cultural, historic and national values of the heritage artifact to the availability of monetary resources. Also, the national/regional conservation and restoration policies (if any) play an important role here as they benchmark the identified risks against the established national/regional tolerance levels.

8.2.4: Proposal of PM process

Restoration projects involve a multitude of competencies and need a team composed of, but not limited to, historians, architects, engineers, social scientists, and managers (Croci, 2000). Managing such diverse teams may prove to be extremely challenging. Therefore, it can be conclusively established that the management of restoration projects stipulates for specialized and customized PM process. Inspired from the work of Croci (Croci, 2000), a detailed lifecycle of restoration projects, as shown in Figure 8-1, is proposed.

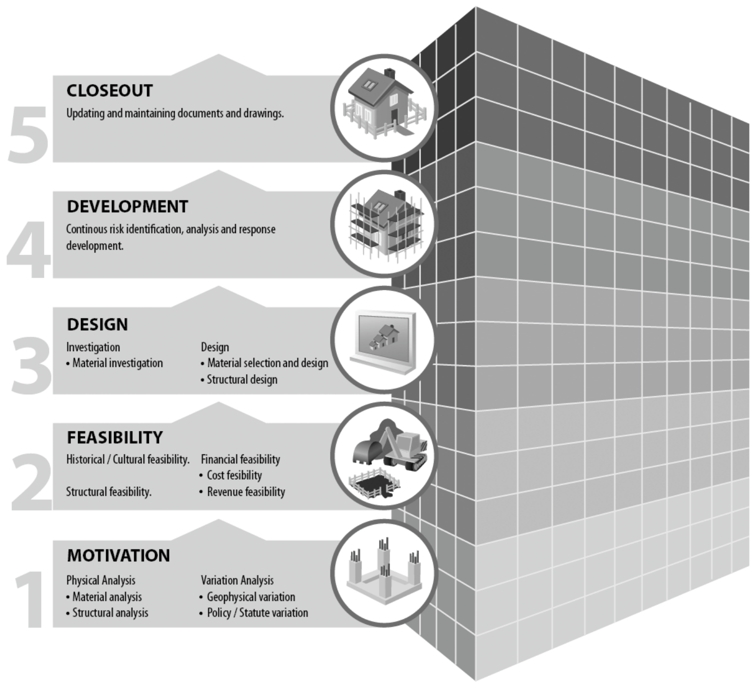

Figure 8-1: Proposed PM process for restoration of built heritage projects

Motivation/Need for Restoration

The process starts with establishing the motivation and the need for restoration. It is probably the most important element of entire PM cycle. It is important to have a holistic and lifecycle view of the reasons which motivate the restoration; keeping in view the environmental, social and economic condition, a thorough study is warranted at this stage. Adding into it, the environmental impact assessment is also proposed in order to gain useful insight into the kind of future uncertainties the building may be exposed to. Thus, in the first phase, the physical analysis (synonymous to *'damage analysis')* is carried out from multiple points of interest. The material and structure are inspected and investigated for damages and decay, and the need to restore is realized. It is important to comprehend the physical damage and its degree before making any restoration decisions. Not only the structure itself, but nearby and tributary areas are also checked for structural and material analysis. Afterwards, a study of variation is carried out where changes in geophysical and political/statutory conditions are examined. The improved seismic zoning has put a number of ancient architecture in earthquake-prone zones which were considered free of this natural force of disastrous nature before. Also, the changes in political and statutory realities may demand for some additional preparation. Often times, the restoration is only motivated due to exogenous changes, as was the case of infamous Pisa Tower in Italy, where the restoration was obligated due to deteriorating ground conditions (Croci, 2000).

Corresponding to this phase of PM and with standard PRM process, risk identification is carried out, which is very important as it will unearth most of the threats and opportunities the project will be subjected to. With reference to Life Cycle Thinking, the risk identification must be aimed at not only the project concerns but beyond. Ranging from visual inspection to interviewing archeological and historical experts, reviewing historical documents to brainstorming and conducting Delphi sessions amongst the experts, this initial stage demands rigorous usage of tools and techniques for affective risk identification. Special attention must be paid on the fieldwork which will promisingly uncover a number of serious issues and risks. Site surveys using modern techniques as well as visual inspection must be carried out in order to familiarize and acclimatize with the structure and nearby area. At the end of this phase, the project stakeholders may obtain a checklist of risks which may also be arranged into a taxonomy for future use.

Feasibility

The second phase of process deals with the feasibility study which aims at establishing the viability of restoration viewed from different perspectives. Once again here, the investigation has to encompass the entire lifecycle of heritage artifact and the attention needs to be all-inclusive in nature. Historical/cultural feasibility tries to ensure that, despite being recognized as cultural heritage, the building being considered for restoration is historically and culturally important or not. Though arguable, the changes in demographics, sociopolitical conditions and behavioral interpretations may render some cultural heritage as *'less valuable'* than other, which paves the way for a study in this area. Also, the present level of structural integrity and its capacity to undergo a 'therapeutic' procedure must be determined (ICOMOS, 2003; Croci, 2000). For this reason, it is important to carry out the structural feasibility of building before making any restoration decisions. This may involve NDT investigation over various structural and nonstructural building components. Lastly, the financial feasibility, in terms of cost and revenues, must also be established; from project point of view, a Cost Management Plan (PMI, 2009) must be established and from a lifecycle point of view, a detailed LCC (lifecycle cost) plan must be established. It is proposed to mimic The Stanford LCCA Procedure (2005) which, although with a focus on the context of greenfield construction, may prove beneficial in terms of organizing and analyzing the various cost and revenue centers.

Although there is a detailed debate around this argument (Greffe, 2004), some authors (Bandarin et al, 2011; Throsby, 2003) consider all cultural heritage buildings as capable of raising revenues and promising economic benefit (Tuan and Navrud, 2008). Further, cultural heritage is also attributed to be of interest in terms of economics: it provides certain benefits and externalities to the areas where it is located. It is further credited to creating significant economic flows, along with being a means of transforming certain geographic areas, and thus providing stimulus to many local and regional economic development strategies and policies (Bedate et al, 2004). Nevertheless, Navrud and Ready (2002) in their seminal work on cultural heritage valuation have analyzed in-depth the economic policy matters that come into play while taking restoration decisions. They raise important questions such as "should the restoration efforts be supported by tax revenues, or should cultural heritage goods be self-supporting, either through user fees or donations and subscriptions?". Therefore, it is important to perform cost-benefit analysis along with other financial and economic investigations before making any restoration decisions as the amount of stake involved and the kind of stakeholders who might be interested in such projects are of varied nature and their interests may not always be in the same direction.

At the end of the feasibility phase, a conclusive decision may be made in favor of restoration activity or vice versa. The PRM proposal for this phase stresses for further risk identification. Apart from interviewing, it is also advisable to perform brainstorming and Delphi sessions by bringing onboard experts from various disciplines, such as architecture, engineering, building, archeology, economics, sociology, and project management. Also financial, structural and historic documents must be reviewed to countercheck, validate and strengthen risk identification. In addition, further fieldwork is suggested in the form of visual logging and site surveys in order to custom-prepare the restoration activities. At the end of this phase, the project stakeholders may revise the taxonomy by updating newly identified risks. Afterward, the PRM proposal suggests performing risk analysis using qualitative approach of brainstorming. The identified risks are further evaluated using their probability of occurrence and resulting impact. Using this as input, the analyzed risks are categorized for further action.

Design Phase

Following the successful precursor feasibility, a design of restoration is planned in terms of materials, structure and restoration technique. The historical materials in most of the cases may not be made available due to a number of reasons. In such a situation, it is important to first investigate for available materials which not only possess characteristics similar to those of historical materials, but are also capable of facing modern challenges and are environmentally sustainable. Consequently, a design phase is carried out where the suitable restoration materials are either selected from a range of available ones or designed on-demand, followed by structural design necessary for the intervention. Later, the restoration techniques are also designed using which the intervention will be carried out. Keeping in mind the fragility of structure, the technique may involve upfront shoring to avoid any collapse which may pose great threat to safety of workers and structure itself. It is important to design and guarantee the structural reliability of the building in the face of new material, possible additional fixtures and loads, and modern protecting techniques, such as retrofitting. Also, the norms and standards of sustainable development must be considered on priority to ensure not only economic and social gains but also the environmental impacts.

During this phase, the PRM includes identification of those risks which are introduced due to design and then analysis of identified risks. Documentation reviews are suggested in order to identify new risks emerging from new materials and design. Material engineers must be equipped with the relevant literature provided by material suppliers in order to point out any possible risk. If the same material is used on some previous restoration, the report may be called from manager and material engineer of the project in order to look for possible problem areas. For qualitative analysis, Risk probability and impact assessment must be performed to rank risks based on their qualitative probability and impact, which must later be managed. For semi-quantitative analysis, probability and impact assessment must be performed where, based on the expert judgment and physical data, risks must be allotted their relative probabilities and resulting impacts. Since all the identified risks can never be managed due to limited resources, therefore only the most significant and threatening risks are responded to. So, the analyzed and ranked risks are further filtered, based on a rigorous Delphi session, for selection of most significant ones for which the effective responses are developed.

Development

After the design, the plan is executed which involves physical activities on the historic building. Development is the regular site work, involving construction and restoration workers and engineers, but the building is more susceptible and at risk during this phase than at any other time. Therefore, the project manager and the risk manager are duty-bound to look for any new risks surfacing due to the ongoing site work. Especially during the phases of deconstruction and dismantlement, it is important to look for any areas of concern, identify risky situations, analyze them and quickly come up with some practical responsive measures. Occupational health and safety concerns must be carefully responded to and the site workers must be fully equipped with necessary personal protective equipment. If the site remains open during the development phase (due to unavoidable circumstances), safe perimeter must be set in order not to let passersby and spectators get any closer to the restoration activities; this will ensure the safety of human subjects as well the structure. Risk identification by visual analysis, site surveys, non-invasive investigation and interviewing the site staff is advisable. For risk analysis, quick brainstorming along with semi-quantitative techniques are suggested, which will help in further proposing the corrective measures.

Closeout

After the successful development of the project, it is closed out. Starting with a detailed intervention report, the entire PRM process is proposed to be documented in this phase, mentioning the risks identified, threats faced and opportunities exploited along with their probability of occurrence and impact of consequence. Also, the corresponding preventive and mitigating measures must be documented. Together with that, other important project documents are suggested to be prepared. Moreover, the layout and as-restored drawings should be prepared to be made part of the record, which may be referred to and reviewed at a later stage or for the next intervention.

Though not falling in the realm of project, a monitoring phase may also be introduced after the project is closed out. The purpose of introducing this phase is to revisit the risk taxonomy (specially the part identified during design and development) and update the pertinent details. The possible advantage behind this cyclic activity may be exploited by the level of preparedness of taxonomy (along with relevant details) in the face of similar projects.

8.3: CONCLUSION

Though with growing threats to cultural heritage buildings and reciprocating restoration projects, practitioners and experts of the restoration industry still find themselves with negligible utilization of formal PM and PRM processes. Moreover, researchers often overlook the penetration of formal methodologies into the literature. Without incorporating the PM and PRM theories – with a successful track record – vulnerability of the restoration projects for not achieving their objectives rises exponentially. Not only the public/private money invested is jeopardized but the integrity and safety of heritage artifact may be compromised harming not only the notions of sustainable development but also the cultural-historic factors.

For improving the efficiency of restoration projects, safeguarding the historical icons and ensuring the sustainable development, a framework consisting of formal PM and PRM processes is proposed in this chapter. The framework, though less sophisticated (because of convenience), is rigorous and involves using tools and techniques with proven affectivity in order to identify, measure and respond to the risk items involved in restoration undertakings. By carefully following the framework, restoration projects of cultural heritage buildings may achieve the objectives in a systematic manner. These objectives may range from integrity of the building, reinstatement of the originality, maintenance of historic and cultural importance, safety of workers, visitors, curators and other human subjects. In short, the application of this framework will help in achieving sustainability not only for the structure itself but also in correspondence with the pillars of sustainable development. Further, the proposed techniques will ensure required level of details for risk identification, analysis and response development.

Based on the novelty of PM and PRM areas of knowledge for the restoration professionals, the framework has been constricted to rather easy and convenient tools and techniques. It is due to the slightly inadequate maturity of the restoration industry in terms of awareness of PM and PRM. In order to improve the efficiency of the current framework, more sophisticated tools and techniques might be included at later stages strongly based on industry acceptance and positive feedback. It is, however, important to mention that the case study of the proposed framework, as detailed in the next chapter, which is a concrete application of the method to a real-life project, appears to sufficiently cover enough ground from the point of view of professionals involved in the project. It is a reasonable situation which not only warrants applicability but also provides necessary incentive to continue research in this area.

Thus, this research is not only an important step towards generating a healthy debate among the restoration experts over the usage of formal PM and PRM practices but goes one step ahead by proposing an application framework which may not be a life-saver in the true sense of the term but provides practical tools and techniques to carry out risk management on a real life project. The possible value addition of this work may be realized in the initial phases of a restoration project where, based on the preparedness offered by applying the proposed framework, the project team and the restoration workers may gain important insights into the kind of scenarios they may be exposed to. The affectivity of application can seriously be augmented if the framework is aided by heritage and environmental impact assessments as these processes can check and help ascertain that the dangerous and negative implications are minimized. The impact assessment and risk assessment, in a way, may be intertwined to help decision makers and stakeholder for making informed decisions.

CHAPTER 9

CASE STUDIES

The purpose of this chapter is to apply the PRM framework proposed in Chapter 8of this thesis. The chapter consists of two case studies: Valentino (Turin, Italy) castle case study which is an ex-post application of proposed framework; and Samma Noble 2 Monument (Necropolis of Makli, Thatta, Pakistan) case study which is performed during site works.

This application is carried out by interviewing the project managers, key project members, architects involved in designing the restoration and site staff. They were asked to identify major risks, analyze them and finally suggest effective responses to control top ranked risks. Application results validate the efficiency and practicability of the proposed framework in the form of effective risk identification followed by analysis. In the light of risk analysis, the proposed framework seems to help the stakeholders to actively control and manage the risks. The research study is mainly applied in ex-post manner; it yet remains to be seen as to how the proposed framework performs for ex-ante application scenarios. Therefore, study results do not reflect issues from the perspectives of projects which are under planning. A similar study that considers application of proposed framework during project motivation and feasibility phases is recommended to validate the research results of this study and applicability of the framework.

Both the case studies are an original effort in applying the PRM framework in real projects in ex-post manner. Based on this and the resulting feedback received from project stakeholders, it may be safely submitted that such an application is deemed highly useful and relevant.

9.1: VALENTINO CASTLE CASE STUDY

9.1.1: Introduction

The need and rationale of introducing risk management in the restoration projects, coupled with the resulting incentive, have been moderately established in the previous chapter. Not only it is necessary to remind the pressing need for a systematic management of restoration risks, it is also opportune to point out towards the sustainability measures ensured due to a formal and organized application of risk management. The purpose of managing risk is not merely to ascertain the timely and in-budget completion of a restoration undertaking, it goes beyond the usual connotation project success and attempts at ensuring the success of restoration activity and safeguarding of structures and buildings attributed with historic and cultural importance. The motivation is to truly achieve project management and project success (Baccarini, 1999).

Further, the validation of proposed model can only be ascertained by applying the amassed academic knowledge into the real world scenario and trying to understand the phenomenon by putting restoration activities into perspective. Thus, in order to test the usability and practicality of the proposed framework, an ex-post application is recommended with reference to the restoration project of the façades in the internal courtyard of the Valentino Castle in Turin, Italy.

The Valentino castle is situated on the north side of the river Po, and forms part of architectural and urban outlook of the city of Turin. It has two distinct façades: the main one, facing the city of Turin, which has the architectural features of XVII century French castles and Italian baroque buildings, while the one facing the river Po is made of fired bricks. Two grand and impressive staircases lead to the first floor, where one can find the Central Hall (Salone Centrale – also known as Hall of Honor or Aula Magna) and the Hunting Hall (Sala della caccia), whose rich stuccoes and commemorative allegorical fresco paintings are the evidence of the ancient shine of the 17th century. The wide courtyard is paved with light and deep cobbles, and its original patterns are still conserved (VALENTINO PARK, 2013).

Although the castle traces its history back to 13th century (the name is suggested to have been first mentioned in 1275 (Castello del Valentino, 2013)), however the first official reference to it dates only to 1543 (Roggero Bardelli and Scotti, 1994). The present castle, originally built as a defense fortress, has undergone a number of transformations and restoration over the centuries. The castle was transformed into a leisure site and later, on the request of Princess Christine Marie of France (1606-1663), wife of Victor Amadeus I, who lived here from 1630, it underwent major architectural and structural changes. The work continued from 1620s till 1660s and resulted in the realization of new towers on the river side, the wings, new façades, and the roofs in French style (Politecnico di Torino, 2012).

In nineteenth century, the castle changed hands from owner to owner: it housed the Veterinary School of University of Turin during the period of French rule until 1814 (Facoltà di Medicina Veterinaria, 2013). Later, with the reinstatement of the Kingdom of Savoy, the castle started to serve royal usage and also as an exhibition center. This change in the use proved architecturally influential and overriding as the structure of the castle was each time modified as a consequence.

The last time the castle underwent a restoration was during 2002 – 2010. This application is exclusive to the works carried out during years 2002 – 2006.

9.1.2: History and Scope of Restoration

The country residence of Valentino - originally built as a defense fortress - was bought by Duke Emmanuel Philibert of Savoy in 1564 as a representative and *'loisir'* – leisure – post. The castle was built according to Baroque style of architecture. It is one of the "Residences of the Royal House of Savoy" and is included in the list of UNESCO World Heritage Sites in 1997.

Turin is a city of endless rows of trees which are a symbol of its typical urbanity. Thus, in order to define and enforce a closer relationship with its host city – through tree-lined streets – the principal intervention on the castle was carried out, requested and commissioned by the young princess Mary Christine of France. The intervention is divided into two periods: 1621 – 1641 by architect Carlo di Castellamonte and then by his son Amedeo di Castellamonte between years 1621 – 1660. During first period, the façade overlooking the river Po was enhanced by a system of stairways and gardens together with new towers on the river side, the wings, and the roofs in French style; the picture taken in 1938 (Figure 9-1) shows this outlook.

Figure 9-1: River side view of Valentino castle in 1938

The site management, thanks to Amedeo di Castellamonte, was put in place since 1641. Also, during that time, front towers, the side galleries and the chamber of access were constructed. The later was demolished in 1821 and is not part of current structure anymore. Other works carried out between 1633 and 1646 include decoration of the first floor apartments with frescoes and stucco (City of Turin, 2013). Expanded and raised into the side galleries, for exhibition purposes, the castle hosted the International Exposition in 1858. Later, in 1859, the building, in its current form (Figure 9-2), was ceded to the Royal School of Application for Engineers, the modern day Faculty of Architecture of the Politecnico di Torino (Politecnico di Torino, 2012).

Figure 9-2: Present Valentino castle

The restoration project, carried out during the years 2002 – 2006, consisted of the restoration of the façades of the courtyard: cleaning, replacement, finishes, paintings, etc. of masonry elements and restoration of authentic balustrades. At its completion, the façades gave a uniform look to various building components constructed and previously restored during different eras, as shown in Figure 9-3. Also the aesthetic inconsistencies due to previous restorations of different eras were removed.

Figure 9-3: Uniform look after the restoration

9.1.3: Application of Framework

This section explains in depth the actual application of the proposed framework. The scope of application is the entire framework; that is to say that all the areas of risk management, as covered by the framework, were worked upon meticulously, which entails risk identification, risk analysis as well the finding of required risk responses. It is also pertinent to mention that the author supervised the application session, offering academic knowledge of risk management and restoration works, the technical and practical expertise came from the team members who had worked in the said restoration project. So, for the ex-post application of the framework, the project manager for restoration was approached for a detailed interview in order to perform identification and analysis of project risks. For brainstorming, along with the project manager, another project team member was invited. The team members were also requested to bring technical documents which may be utilized to discover pertinent details of previous interventions. In the following sections, the proposed framework is applied, and the findings and implications are documented.

Risk identification

Risk identification is the process of identifying potential risks before they threaten the objectives of the project and put at stake the reputation of stakeholders and associated/interested parties. As proposed by the framework, interviewing, brainstorming and documentation review are some of the most relied upon risk identification techniques. For this case study, the author utilized interviewing and documentation review techniques. Both team members of the restoration project were interviewed individually, as well as a joint session was conducted. Further, the documents brought by them were initially studied by the author and then discussed with them during individual and joint interviews. This provided an extremely balanced yet broad view of the tumultuous nature of their responsibility and the uncertainties faced by them.

Using the ‘interviewing’ and ‘documentation review’ techniques, the following risks were identified at each stage of the project lifecycle, which are tabulated in Table 9-1, in the form of a risk register, along with their description.

Project Phase	**Risk**	**Description**
Need and Motivation	number of physical tests of components	due to perceived fragility of the building components and unavailability of knowledge of material used in previous works, physical tests were limited to very few which restrained the capability to explore any potential risks; inappropriate test scheduling: the weather conditions created some unforeseen and considerable situation (dampness, plaster and color depletion etc.) which got in the way of clearly understanding the building condition
	unavailability of knowledge of previous restorations and interventions	even after taking help from the historic documents, the ‘documentation review’ was unable to provide detailed knowledge of previous interventions
	unavailability of knowledge of materials and products used in previous restorations and interventions	due to adopted prudence – forced by safety culture, and national and international health and safety regulations, the missing knowledge of materials used during previous interventions was a critical factor
	limited budged	being a public project, the scarcity of budget was a rampant problem
Feasibility and Design phases	case history of building and its components	missing information of previous interventions and as-built drawings raised concerns regarding design of new intervention actions
	homogeneity of previous restoration/intervention	since the castle in general has had a long history of construction and reconstruction, the uniformity of look was a challenge

	the choice of appropriate therapy	in the face of unavailability of past information and partially investigated building components, it was a challenge to decide the intervening therapy that not only respects the fragility of structure but is also reliable
	choice of color	the missing uniformity of outlook caused a selection problem, experts were divided between maintaining the originality and enforcing the consistency of color
	lack of standardized, established and verified therapy	as mentioned before, along with the relevant legislation, the restoration industry is also witnessing an evolution of standardized intervening therapy, which may encapsulate the standard techniques to dismantle, repair/maintain and reassemble/reconstruct the building components
Development and Execution phase	change originated by controlling authorities	since the legislation concerning the restoration is evolving, it was a risk to incorporate the variations elicited from key stakeholders
	unhealthy materials and products used during previous restorations or interventions	once the dismantling could be done, the risk of unhealthy and substandard materials and their exposure could pose serious health and safety risk
	rapid changes in technology for surface finish products	with advancement in the material engineering, better and convenient products are introduced for surface finishes, thus due to this rapid change it was challenging to select the *'best'* product which may stand the test of time
	need for unanticipated large scale test material samples	owing to the antiquity of castle, NDT (nondestructive testing) was mainly done which meant tests were carried out – simultaneously, at a large scale – once dismantlement of required building components was done
	breakdown of previously restored components during the work	healthy and safety concerns were raised due to possibility of breakdown of old building components during dismantlement and reconstruction
	site logistics problems due to continued academic activities	since the castle is an active education center, the restoration activities faced logistic challenges due to constant human presence and movement

Table 9-1: Risk register for Valentino castle project

It can be observed that a total of 15 risk items were identified, with majority falling into the "Development and execution phase". Part of the reason may be attributed to the slightly misplaced definition of the term risk; as practitioners usually tend to associate risk mainly with negative outcomes, the actual site work is deemed more uncertain and risky in restoration projects. Another contributing factor is the lack of previous knowledge due to which the structural and material information is kept undercover unless unleashed. Thus, it can be argued that difficult site conditions and execution activities are at the core of uncertainty when it comes to restoration projects.

Further, the misdirection of understanding of risk (and its association to negative outcomes only) is additionally evident from the fact that all identified risks were negative in their nature. Even after strong motivation from the author, project team members found it practically impossible to identify a single risk with possible positive outcome. This advocates for the introduction of formal risk management education in the restoration sector in order to empower the practitioners to not only identify the positive risks but also exploit them to gain maximum benefits.

Risk analysis

At the end of successful risk identification phase, the next step in formal risk management process is to analyze the identified risk items. The process of risk analysis is aimed at quantifying and categorizing risks based on the frequency of their occurrence and potential severity of their impact. This process facilitates in better and effective decision making; it allows to select and further treat the more dangerous, hazardous and high-impacting risks rather than treating all or none. Management literature suggests that inability to measure is tantamount to unlikelihood to manage. Thus, the process of risk analysis measures the seriousness of a risk and allows decision makers and prime stakeholders make informed and efficient decisions.

The risk analysis was performed using qualitative and semi-quantitative approaches, as proposed by the framework, for systematically evaluating and investigating further into the identified risks. Since it is not practical to manage and control all the identified risks, the ones which come out as *'serious'* and *'critical'* are taken forward for further treatment. First, the qualitative risk analysis was performed using the brainstorming technique in order to rank the identified risks according to their significance and impact. The project members were encouraged to discuss each risk in its details and were facilitated by the author, wherever needed, to understand the management terminologies. The guiding principles or assessment criteria for this ranking analysis, binding with sustainability, were following: safety and health of people from damage that may occur during the restoration works; preservation of building heritage, components and materials; and budget respect. If analyzed carefully, the three guiding principles are at the core of sustainable development; they ensure the efficiency and benefit to society, environment and economy.

Based on these decisive factors, the brainstorming activity produced the top four risks as following:

1. Availability of knowledge of materials and products used in previous restorations/interventions;
2. Case history of building and its components;
3. Unhealthy materials and products used during previous restorations/interventions;
4. Lack of a standardized, established and verified therapy;

It is important to understand that the case study was mainly carried out to ensure the practicability of the framework and not provide solutions. Therefore, both team members, after lengthy brainstorming, were asked to provide top 2 risks according to their perception. Thus a list of 4 risks was obtained. However, the analysis could result in more risks at the lower ranks of the list but it is assumed that this much of the details serve the purpose which is to illustrate the application.

Afterward, the semi-quantitative risk analysis was performed using the probability and impact matrix technique (PMI, 2009) to further rank the risks in terms of their significance on a scale "High-Medium-Low", as shown in Table 9-2. Once again, the project members were encouraged to provide their perceived and experienced likeliness and resulting impact of ranked risks.

Risk	Probability	Impact	Rank
1	3	4	H
2	2	4	M
3	3	4	H
4	4	4	H
Probability Scale: 1 – V. Low, 2 – Low, 3 – Medium, 4 – High, 5 – V. High Impact Scale: 1 – V. Low, 2 – Low, 3 – Medium, 4 – High, 5 – V. High Risk Rank Scale: H – High, M – Medium, L – Low			

Table 9-2: Semi-quantitative risk analysis using Probability and Impact Matrix

The semi-quantitative analysis provided three *'High'* ranking risks (risks 1, 3 and 4) and one *'Medium'* ranking risk (risk 2). Depending upon the contextual and organizational culture and maturity, specific rankings are treated in the following ways: fully mature and risk-averse organizations tend to manage and control medium and high ranked risks; whereas, less mature organizations or industries, where PRM penetration is minimal, tend to treat only the high ranked risks which pose greater threat. In any case, the risk treatment presented in the next section followed a more rigorous approach and responses were identified for all top four risks (ranked both 'high' and 'medium').

Risk response development

The purpose of risk management is to eventually come up with preventive and mitigating measures for negative and threatening risks, and exploiting and fostering measures for positive risks. Developing strategies and actions for the analyzed risks is at the core of responding to these risks. The development of these strategies and actions, apart from the severity and importance of risk items, takes into account the resource availability along with predetermined tolerance levels by the prime stakeholders. Not only the organizational understanding and attitude towards risk come into play, but also the broader perception of community when it comes to managing restoration risks, owing to the value and importance of these cultural buildings.

Thus, for the purpose of this case study, the project team was further interviewed for identifying and developing potential responses in order to respond to the high and medium ranked risks. Since the restoration industry is not formally and fully exposed to PRM, the project team was briefed about the importance of their role in risk response development: it was explained to them that risk management helps in understanding and analyzing the risks, but the responsibility of responding to those risks still lies on their shoulders. Based on their experience and knowledge of restoration projects, the following responses were mentioned by the project team in order to affectively react to each risk:

1. In order to respond to the risk of unavailability of knowledge, cataloging of previous as-built case studies and analogies is suggested;
2. Previous experience of restoration experts is suggested to be referred to in order to gain background of building and its components;
3. Human damage due to unhealthy materials and products can be avoided by appropriate protection of site workers;
4. In order to respond to the lack of standardized therapy, other restoration works are suggested to be tracked over the time.

9.1.4: Discussion

Following the proposed framework, the risk analysis was performed during the main phases of the project lifecycle. The input from the project team in the form of interview and brainstorming was instrumental for not only identifying and ranking the risks, but also for developing effective responses to risks and plans to mitigate potential impact and probability of risk events. Due to unavailability of appropriate and more useful historic documents, the process of documentation review could not reveal and generate much helpful information. Of all the identified risks, three were ranked as 'High' and one as 'Medium'. Prevention actions were then developed for these four significant risks as plans for risk reduction and mitigation. It is important to mention here that all identified risks were hazardous (and negative) in their nature mainly due to not-so-well understood and appreciated description of risk. The traditional understanding seemed to take over the modern one, which advocates for active dissemination of project management and risk management knowledge areas into restoration and architectural sciences.

The applicability of the proposed framework can be established from the fact that almost all the proposed identification and analysis techniques have efficiently brought useful results: interviewing has revealed almost all the risks faced by the project; documentation review however, in the purview of available resources, could not efficiently uncover major risks – it only helped in gathering the history of castle; brainstorming ascertained the qualitative ranking of the risks and produced a list of four most significant risks; finally, the semi-quantitative analysis, using probability and impact matrix, has further classified and reasserted the risks into high and medium categories. The project manager vouched for the fact that the three 'high' risks, as analyzed by the framework, were actually significant and handled carefully but intuitively and unsystematically, spending more resources and, as a result, compromising productivity.

9.1.5: Conclusion

This chapter presents a case study of ex-post application of proposed PRM framework on the restoration project of Valentino castle. This case study acts as the application guidelines for the utilization of proposed PRM framework on a restoration project. It embodies the processes and phases of risk management for a restoration project starting rom risk identification to the development of necessary preventive, mitigating and exploiting measures to respond to these risks. By mimicking the step followed in this chapter, practitioners may conveniently and effectively manage risks in their respective restoration projects.

The objective of this application was to ascertain the applicability and efficiency of the proposed framework. For that purpose, the project manager, along with a key project member, was invited to participate for this application. This activity helped in identifying some very important risks, such as: availability of knowledge of materials and products used in previous restorations/interventions; case history of building and its components; unhealthy materials and products used during previous restorations/interventions; and the lack of a standardized, established and verified therapy. Further, the activity enabled the author in analyzing the identified risks using qualitative and semi-quantitative approaches. Finally, effective risk responses were developed for reducing and controlling the risks. Due to the ex-post nature of this case study, the cyclic 'monitoring and control' process of standard risk management could not be performed. However, the feedback from the project team regarding the all-inclusiveness may partly substitute and replenish for the missing process.

The application was attempted to be precise, detailed and authentic as much as possible. The feedback provided by the project team for this ex-post application is encouraging: based on the comments, it can be concluded that the efficiency of the proposed framework leaves a satisfactory impression and the project team is intrigued by this innovative approach. This shows that the proposed framework does not go against established philosophies and protocols of the restoration industry, but it improves them by formalizing and systemizing the restoration process. It adds the flavor of management into excessively technical field of cultural heritage restoration which may enable and facilitate a paradigm shift towards these projects by bringing onboard the project and risk management professionals.

However, the current application of the framework is restricted to an ex-post activity. It is suggested as continual work to apply the framework to a running project, where it will be interesting to discover and observe the effects on not only the risks but also on the overall project productivity in terms of sustainability drivers as it is believed that affective PRM application may help in ascertaining in sustainable restoration, paving a way towards sustainable development.

9.2: MAKLI NECRIPOLIS CASE STUDY

9.2.1: Introduction

In Islamic architectural, the funerary memorials are typically termed as either tombs or mausoleums. Nevertheless, the notion is not exclusive to Islamic traditions only; other religions have also demonstrated the tendency to celebrate such places at some point in time in their history. In the Islamic traditions however the tombs were beautifully decorated and methodically designed, using lot of human labor for constructing these edifices for the dead (Junejo, 2012). The tombs and vast spread necropolis beg a lot of architectural attention – roughly, second to mosques. These tombs have become a site of pilgrimage, causing a constant usage scenario which aggravates their structural integrity. The dismal condition posed by a majority of heritage sites, unfortunately, does not tell an encouraging tale in contemporary Pakistan. Part of the problem is the civil awareness of people living near and visiting these sites; the culture of treating these historic places as '*national assets*' has yet to find its way in the psychology of a common citizen of Pakistan.

However, Pakistan has been the cradle of civilization due to being a part of Indian subcontinent which dates back more than five millennia in the recorded history. Over the centuries, through successive waves of migrations and conquests from the North West as well as by internal migrations across the Sub Continent. Aryans, Persians, Greeks, Arabs and Mughals, Arghoons and Turkhans among others got here and made it home; their architectural legacies, and remnants are spread all over the length and breadth of

Pakistan today, some in miserable conditions and a few near to extinction. However, some are being preserved as well.

Makli is one of the largest Muslim necropolises in the world. It has a diameter of roughly 10 KM and is located near the historic town of Thatta (UNESCO, 2013). The total area of larger graveyard is far bigger than this: the aerial distance between the clustered graveyard at Makli and farthest known mausoleum - Pir Patho - is more than 20 KM but due to extremely sparse presence of graves in between, only the concentrated portion of Makli is taken into account. The construction of earliest Sufi monasteries and mosques dates back to fourteenth century when Thatta was ruled by Samma dynasty (Lākho, 2006). Several of these structures are still standing today, although their condition is vividly poor. The elaborate and detail-designed tombs are a testament to the architectural and civil wealth of Thatta, which was an active commercial hub in the Middle Ages; the town is also boasted as the center of knowledge and education in the past (WIKIPEDIA, 2013). Thatta and the Makli Tombs were inscribed on the World Heritage List in 1981 due to architectural marvels located there. A short glance is offered in Figure 9-4, Figure 9-5, Figure 9-6and Figure 9-7. The maps of Samma cluster is shown in Figure 9-8

Figure 9-4: View of stone built canopies and open graves, ca. Samma period

Figure 9-5: Tomb of Jám Nizámuddín II – the detailed stone carving work

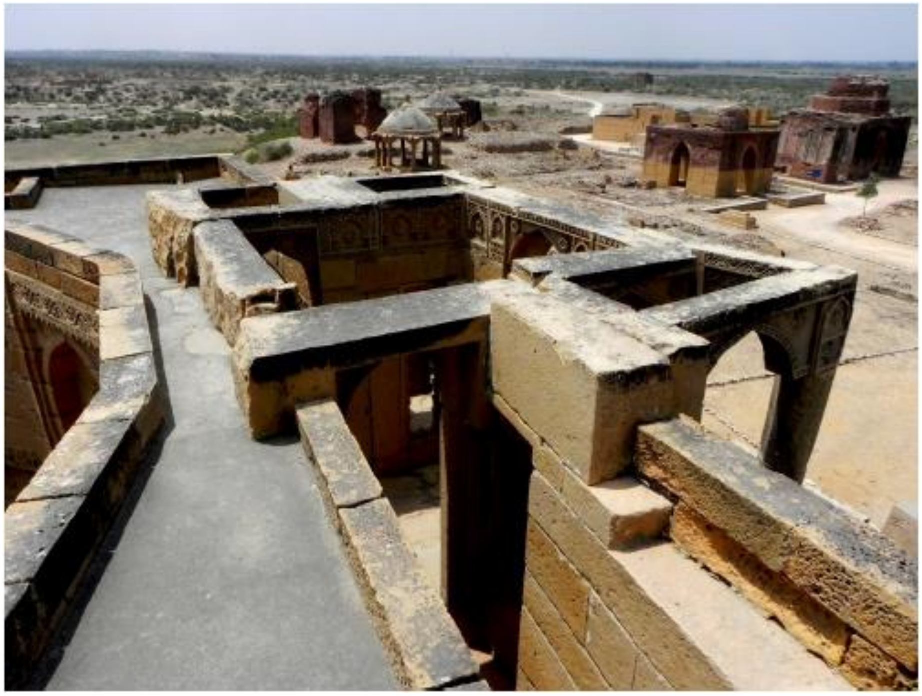

Figure 9-6: View of funerary monuments - the Samma Cluster

Figure 9-7: Stone masonry tomb and the courtyard of Mirza Essa Khan Tarkhan, ca. Tarkhan period

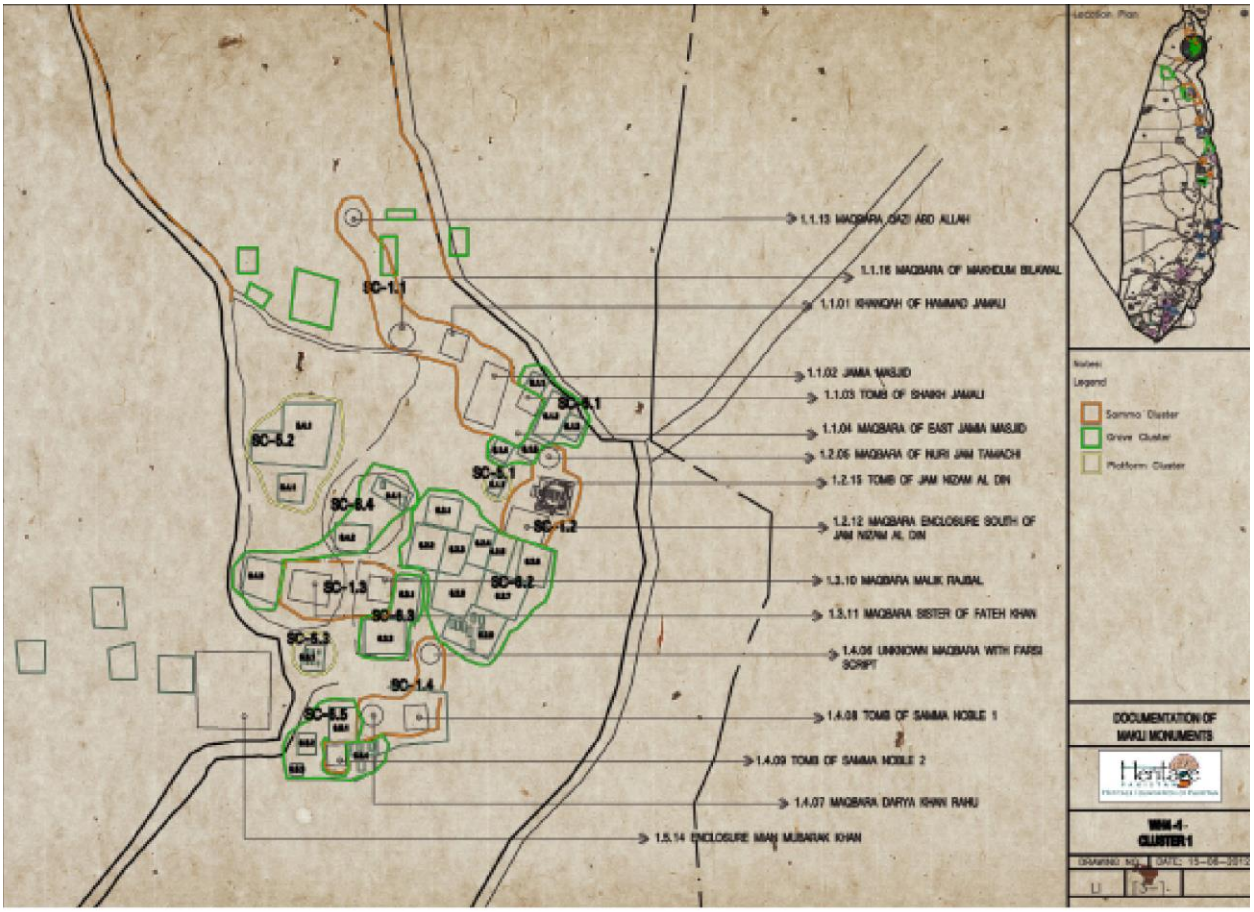

Figure 9-8: Mapping of the Samma Cluster

An overwhelming majority of these monuments are in *grave* condition and warrant for serious national and international attention. UNESCO's convention on the protection of the world cultural and natural heritage, in their 37th session, held in the month of June, 2013 in Cambodia, encouraged the State to invite an ICOMOS/ICCROM advisory mission to the site in order to assist in the following (WHC, 2013):

1. *develop a comprehensive program for conservation and stabilization of the most threatened monuments,*
2. *finalize the boundaries of the property and its buffer zones,*
3. *define the objectives of a Management Plan for the property to address critical issues, including disaster risk management and public use,*
4. *elaborate a capacity building strategy with a view to reinforcing national capacity in the field of heritage conservation and management.*

Hence the state of conservation activities and a pressing need to manage them scientifically cannot be overstated.

9.2.2: History and Scope of Restoration

The restoration of Samma Noble I, other than a myriad of reasons, was chiefly motivated after the huge losses incurred to the site during the floods of 2010 (Tribune, 2011). It is not that the tomb was in perfect condition before; the historical evidence suggests that the site has remained in depleted condition in the past as well, as illustrated in Figure 9-9, but the situation was aggravated after 2010 floods. All the monuments suffered extensive damages due to excessive rains, flooding and the subsequent influx of 450,000 people who took refuge from the floodwaters and camped at the site.

Figure 9-9: The tomb of Samma Noble I as photographed in 1980s

After their return in the spring of 2011, a review of the extant structures was undertaken through a Damage Assessment Mission by The Heritage Foundation Pakistan (HF). The Prince Claus Fund financially supported this initiative. HF, under the apt leadership of Arch. Yasmeen Lari, took the charge of restoration project (Restoration of the Tomb of Samma Noble I, 2011). The ruined condition of this site, though hopeless at times, needed a detailed plan for the restoration works and therefore it was deemed necessary to use the information gathered during the Damage Assessment Mission to implement repairs to the extant parts of the Samma Noble I tomb before its brick masonry walls degrade to a point beyond repair. Figure 9-10 shows the state of the tomb at the time of this critical decision making.

Figure 9-10: The tomb of Samma Noble I as photographed in 2011

Figure 9-11: The underpinning activity executed on site

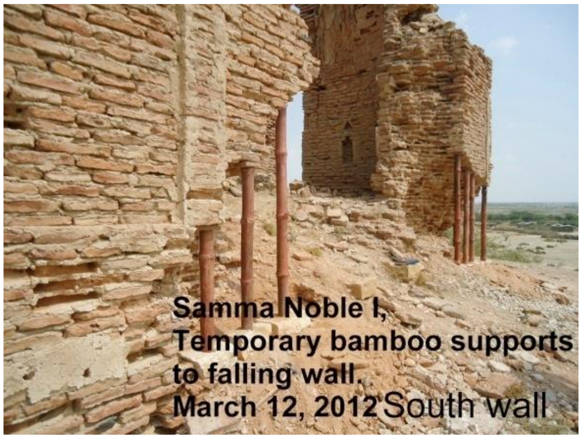

Figure 9-12: The side views of underpinning activity

The results of the Damage Assessment Mission indicated that the tomb was one of the most highly degraded structures and needed urgent attention. As a response, HF put in place a site office along with local experts in order to recover the architectural state and structural integrity of the site. The plan was to provide instant underpinning, stabilization and re-pointing measures which could protect the delicate brick masonry walls and stop further settlement and damage. Figure 9-11 and Figure 9-12 show the underpinning activity executed on site.

9.2.3: Application of Framework

In order to apply this framework, author had a detailed meeting with the person in charge of the project, Arch. Yasmeen Lari, along with Arch. Marvi Mazhar and the site staff including project manager. This section explains the application of the proposed framework on the restoration project. The application is partially ex post and partially during execution. All the areas of areas of risk management, as covered by the framework, were worked upon. It is also pertinent to mention that the author supervised the application session and the level of agreement between the chief expert and author remained uneven. However the project experts found the systematic knowledge as enabling an informed decision making. The detailed interview also covered the large practice issues in the realm of architectural restoration in

Pakistan. Separate brainstorming sessions were conducted: in the project office with chief architect and at the site office with project manager. The application of framework was mainly facilitated by interview and brainstorming, no review of technical and/or historical document was performed. The following sections elaborate the application, findings and the implications.

Risk identification

The framework suggests interviewing, brainstorming and documentation review as some of the most useful and efficient risk identification techniques. In this case, as mentioned earlier, only the first two techniques were used. The team members were asked for the risks of the project and the data was recorded. Being a very simple structure, the structural complexities were naturally low and therefore the risk identification exercise brought up only few risks – all of them as major. Table 9-3shows the identified risks along with their description.

Risk	Description
lack of respect for the heritage sites	as stated before, the experts also seemed concerned about the general atmosphere regarding protection and preservation of cultural heritage sites
lack of governmental and institutional support for such projects	the experts voiced their opinion about the severe dearth of support from government and other relevant institutions which causes a slow and steady demise of such sites
unavailability of knowledge of previous restorations and interventions	in the absence of historic documents and almost entire lack of culture of documenting the past data, knowledge about the previous restorations was not available
unavailability of knowledge of previously/originally used material	although of low significance due to simple design, the project team could not figure out the details of previously used material
limited budged	being a funded project as part of public sector spending, the budget was very limited
unavailability of trained workmanship	restoring such an old and fragile structure warranted for expert hands
breakdown of previously restored components during the work	healthy and safety concerns were raised due to possibility of breakdown of old building components during dismantlement and reconstruction
site logistics problems due to	local law and order conditions made it hard to work at the

law and order conditions	site, frequent theft of material and equipment was reported along with the mischief by the local people

Table 9-3: Risk register for Makli project

Risk analysis

The risk analysis in this case was performed only using qualitative technique – the brainstorming technique in order to rank the identified risks according to their significance. The project team actively participated, however it is pertinent to mention that the session was very informal in its setting; this was done to grasp most of the information. Especially in case of site staff, the data was collected while visiting the site.

The risk analysis ranked the following identified risks as the most significant:

1. Limited budget
2. Unavailability of trained workmanship
3. Unavailability of knowledge of previously/originally used material
4. Site logistics problems due to law and order conditions

It is imperative to state here that, on a general level, experts were more concerned about the overall culture and lack of support. But since those risks fall outside the purview of this application, they are not mentioned in the list.

Risk response development

The project team was further requested to come up with the remedial measures which can be applied for the identified risks. In almost all the cases, these strategies had been actively applied by the site team, which gives a chance to figure out the affectivity of proposed risk responses. Based on their experience and knowledge of restoration projects, and their past exposure to the current activity, the team members proposed the following risk responses for each risk:

1. Since the HF is a private organization, the risk of limited budget was accepted and the team relied upon local means to reduce the costs.
2. The project team considered themselves lucky as the trained workers found them, not the otherwise. As reported by the project manager, the *Department of Archaeology and Museums* – a federal entity of Government of Pakistan – had trained such people in the past in order to ensure locally available workmanship.
3. The good luck worked further and the experts in labor informed the project team about the possible solution – a highly cohesive and non-granular soil found at another famous archeological site – *Moen Jo Daro* – some 400 KM from site. The brick making assembly was installed at a nearby site and lime stone was used as mortar. The project team was proud in reporting that their

solutions are economical, locally available and environmentally friendly; fulfilling all the requirements of sustainable development.

4. Local authorities along with elders were involved in order to ensure security for the site staff.

9.2.4: Discussion and Conclusion

This case study was performed in order to find out the local application of the proposed framework; it was an attempt to ascertain the uniformity of use and function offered by the framework. The experts at the office, mainly Arch. Lari, were of the opinion that the framework needs more integration into the architectural foundation. In response, it was argued that the framework finds its application in the realm of architectural restoration only; it is otherwise based on the tested and trusted theories of project management – and those too in the field of construction. On a positive note, the experts showed a sense of satisfaction over the breadth of focus offered by the framework – from cradle to grave of a project.

The application somehow remained quite restricted due to intellectual differences and disagreement over the definition of technical terms; however, from the author's point of view, the team was doing all that the framework advocates but using different vocabulary.

This is in line with the initial hypothesis that there is severe lack of knowledge integration between restoration and project management areas. In the beginning, such exercises might have to take a lot of cold shoulder, it is expected that once the discussion is mobilized, such minor intellectual conflicts may be worked upon for the general benefit of the restoration industry and the historic sites.

The general demeanor of the participants during both case studies has been extremely encouraging partly due to their academic affiliations and proximities, and partly driven by the expectation of some valuable and helpful contribution in their area of practice. It is not necessarily aimed here to provide a *killer* solution as an end result; in spite, the aim is to mobilize and integrate the existing knowledge in the various areas and culminating into an operational framework for facilitating the restoration projects by intelligently understanding the strengths and weaknesses as well as borderline notions in the realm of architectural restoration.

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