

# A review on Risk Management in Sustainable Construction

Gunarathna U

*Department of Quantity Surveying, Faculty of Built Environment and Spatial Sciences  
General Sir John Kotelawala Defence University, Sri Lanka*

<udari.gunaratne@gmail.com>

**Abstract**— Construction industry is highly risk prone, with complex and dynamic project environments creating an atmosphere of high uncertainty and risk. Meantime, sustainable construction aims to meet present day needs for building, working environments and infrastructure without compromising the ability of future generations to meet their own needs in times to come. It incorporates elements of economic efficiency, environmental performance and social responsibility and contributes to the greatest extent when architectural quality, technical innovation and transferability are included. Researches have been investigated the strategic importance of risk management in construction industry with the perspective of associated stakeholders. Hence, the integration of risk management in sustainable construction has not been taken into account even though the necessity of such integration has been discussed. Since, the sustainable construction refers to both a structure and the using of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition, a coherent model is needed to align both risk management and sustainable building construction which will explore the sustainable concept throughout the construction industry without uncertainty. This paper reports on case studies of five sustainable construction projects, which were using up to date sustainable construction practices. Data was collected by interviewing five participants from each of selected sustainable construction projects. Based on the case study findings, a model was developed for sustainable risk management by amalgamating both risk management and sustainable construction. The developed model will lead to an effective risk management practice that could be used in sustainable construction industry by enhancing how the risk management strategies incorporate with sustainable construction.

**Keywords**— Construction industry, Sustainable construction, Construction practices, Risk Management

## I. INTRODUCTION

### A. Background

“Sustainability” is one of the world’s most talked about but least understood words. Its meaning is often clouded by differing interpretations and by a tendency for the subject to be treated superficially (Syed et al., 2012). For most companies, countries and individuals who do take the subject seriously the concept of sustainability embraces the preservation of the environment as well as critical development-related issues such as the efficient use of resources, continual social progress, stable economic growth, and the eradication of poverty.

Meantime, as per BRE Environmental Consultancy (2008), in the world of construction, buildings have the capacity to make a major contribution to a more sustainable future for our planet. Therefore, it is clear that sustainable buildings have become vital cornerstones for securing long-term environmental, economic and social viability.

Sustainable construction aims to meet present day needs for housing, working environments and infrastructure without compromising the ability of future generations to meet their own needs in times to come. It incorporates elements of economic efficiency, environmental performance and social responsibility – and contributes to the greatest extent when architectural quality, technical innovation and transferability are included (Bing et al., 1999).

Furthermore, sustainable construction involves issues such as the design and management of buildings; materials performance; construction technology and processes; energy and resource efficiency in building, operation and maintenance; robust products and technologies; long-term monitoring; adherence to ethical standards; socially-viable environments; stakeholder participation; occupational health and safety and working conditions; innovative financing models; improvement to existing contextual conditions; interdependencies of landscape, infrastructure, urban fabric and architecture; flexibility in building use, function and change; and the dissemination of knowledge

in related academic, technical and social contexts (Akintoye et al., 1997).

Researches of Ling and Hoi (2006), have been investigated the strategic importance of risk management in construction industry with the perspective of associated stakeholders. Hence, the integration of risk management in sustainable construction has not been take into account even though the necessity of such integration has been discussed by LafargeHolcim Foundation (2015). Since, the sustainable construction refers to both a structure and the using of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition, a coherent model is needed to align both risk management and sustainable building construction which will explore the sustainable concept throughout the construction industry without uncertainty.

Thus, by taking above factors into account this research aims to manage all these risks with in a frame of risk management model.

## II. METHODOLOGY AND EXPERIMENTAL DESIGN

This study has adopted qualitative research approach, the essence of which, according to Wigren (2007), consists of focusing on understanding the naturalistic setting, or everyday life, of a certain phenomenon by the investigator. Qualitative methods are essentially descriptive and inferential in character and focus primarily on the kind of evidence that will enable to understand the meaning of what is going on. Accordingly, among various approaches available in the qualitative approach, case study (Yin, 2003) has been selected.

The case study research method provides an in-depth investigation by studying 'cases' in an uncontrollable environment. According to Yin (2003), case studies are the preferred strategy when 'how' or 'why' questions are being posed, when the investigator has little control over events and when the focus is on contemporary phenomenon within real-life context. Considering these points, the case study method was seen as suitable for this study.

In this study, cases were selected from construction industries, which are focusing on the concept of sustainability. Accordingly, three buildings were selected. From each case three semi structured interviews were

conducted with three representatives from top management and middle management.

Altogether, 15 interviews were conducted and each normally lasted for 30 minutes to 45 minutes.

Table 1 provides the case studies and interviewees' details of the sustainable construction projects that were taken into account with the intention of collecting more accurate data for the research project.

Selected projects can be classified as a two hotel projects, apartment project, Office complex and a factory project respectively. Among these five projects two were on-going project and other three were completed projects under the concept of sustainability.

**Table 1. Details of Case Studies**

Project	Project A	Project B	Project C	Project D	Project E
Project type	Hotel Building	Apartment Complex	Factory Building	Office Building	Hotel Building
Interviewees	General Manger Project Manager Green Consultant	Project Manager System Manager Assistant System Manager	General Manager Project Manager Green Consultant	General Manger Project Manager Architect	Project Manager Assistant System Manager Facility Executive

Key themes (codes) emerging from the findings were identified within each case and replication of findings were tested using 'cross-case analysis.' The research results are presented and discussed next.

## III. RESULTS

### A. Risk Management in Construction Industry

Risk management in construction projects is a vital factor. From the starting point of a certain project, risks are involving and a proper risk management strategy is needed. In the planning phase possible risks for the subsequent project success can be identified and reduced through their incorporation into the planning. This has in particular effects on the observance of set dates and deadlines and also on the maintenance of the project costs.

For the principal, observance of its due date for putting into service an operating unit is of great importance. The risk potential analysis of a project states to what extent project risks influence the risk situation of the enterprise.

Risk potential should be estimated without a detailed consideration of the individual risks at as little expense as possible. Depending on the assessment of the risk potential, the risk management process is set in motion. Risk management comprises the integration of basic principles of risk policy, the establishment of a risk consciousness as well as the organizational integration.

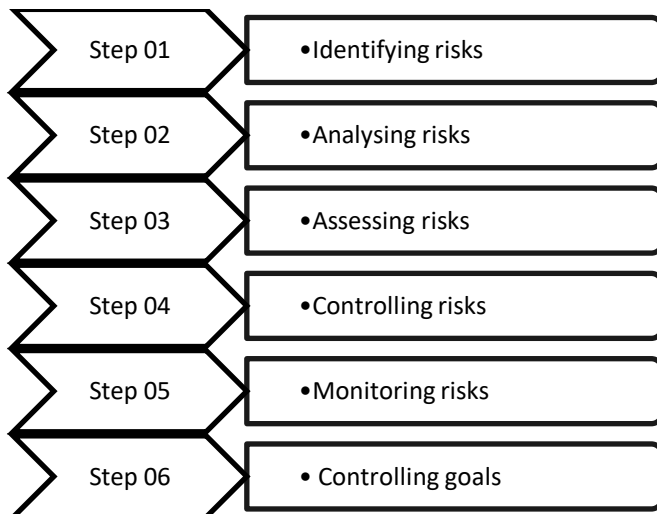
It is an impetus for the risk management process and is responsible for the control of risks in full knowledge of the current risk situation. Through risk management, transparency increases, many problems can be avoided from the outset through proactive action, the project can be prepared for unavoidable problems. Through this, the consequences can be mitigated, and the project manager retains the control over his / her project.

In accordance with the case study findings, following process can be identified as the risk management process of traditional construction projects.

Basically, six (6) steps are in use to manage potential risks in the field of construction.

*B. Process of Risk Management in Construction Industry*

**Figure 1. Process of Risk Management**



*C. Types of risks in Construction industry*

Risks can be either acceptable or unacceptable. An unacceptable risk is one which has a negative impact on the critical path of a project. Risks can either have short term or long term duration. In case of a short term risk, the impact

is visible immediately, such as a requirement change in a deliverable.

The impact of a long term risk is visible in the distant future, such as a product released without adequate testing. Risks can also be viewed as manageable and unmanageable. A manageable risk can be accommodated, such as a small change in project requirements. An unmanageable risk, on the other hand, cannot be accommodated, such as turnover of critical team members. Finally, the risks can be characterized as internal or external. An internal risk is unique to a project and is caused by sources inherent in the project; example can be the inability of a product to function properly. Whereas, an external risk has origin in sources external to the project scope, such as cost cuts by senior management.

*D. Sustainability and uncertainty relation in a construction project.*

Sustainable projects are followed by uncertainty in different means. One aspect of the future is obvious: all new construction projects will be accomplished in an increasingly complex technical, economic, political and social environment. Nowadays, it is confirmed that successful delivery processes planning, design, construction, and operations for sustainable projects are generally more complex and have more stakeholder interactions than delivery processes for their traditional counterparts are namely a major source of uncertainty in all stages of the Project Life Cycle and that the complex processes for delivering sustainable projects are often unfamiliar to them, uncertainty and risk management, especially in relation to stakeholders becomes very significant for sustainable projects.

Stakeholder-related uncertainty for sustainable project should, as for traditional one, encompass who the relevant stakeholders are and how they can influence a project. From an uncertainty management perspective, the purpose of defining and managing stakeholders is to reduce threats to project performance, and to pursue opportunities for Pareto improvements in the nature of project activities and the ultimate outcome of a project.

In accordance with all the three projects that were taken in to account, risks associated with the construction industry can be broadly categorized into; technical, logistics, management related, environmental, finance and sociological risks.

With the statements of all the project managers and other top hierarchical stakeholders' in all projects, this categorization can be briefly illustrated as follows.

*I. Technical risks:*

- Inadequate site investigation
  - Incomplete design
  - Inappropriate specifications
  - Uncertainty over the source and availability of materials
- II. *Logistical risks:*
- Insufficient transportation facilities
  - Absence of resources-particularly construction equipment spare parts, fuel and labor
- III. *Management related risks:*
- Uncertain productivity of resources
  - Industrial relations problems
- IV. *Environmental risks:*
- *Weather and seasonal implications*
  - *Natural disasters*
- V. *Financial risks:*
- *Fluctuation in foreign exchange*
  - *Delays in Payment*
  - *Inflation*
  - *Local taxes*
  - *Repatriation of funds*
- VI. *Socio-political risks:*
- *Customs and import restrictions and procedures*
  - *Difficulties in disposing of plant and equipment*
  - *Insistence on use of local firms and agents*

Therefore, considering the sustainable building construction all these above risks are there with some additional risks and uncertainties which are playing a vital role in the scenario of sustainable construction.

#### *E. Risk Categories in Sustainable Construction*

Based on this concept, numerous issues have been identified by the stakeholders in the construction project itself, which serve as the basis for the sustainable construction. With reference to the project managers in project A,C and the green consultant in the project B, "we have identified number of issues that we called risks in our green projects in variety of ways". All these identifies risks are listed below as per the sustainable projects that have taken into consideration.

##### *I. Novelty and transferability – Development*

As per the project manager in project A, "Projects must demonstrate innovative approaches to sustainable development, pushing the envelope of practice and exploring new disciplinary frontiers". Furthermore,

Breakthroughs and trend-setting discoveries must be transferable to a range of other applications.

Under this innovation and transferability, sustainable construction projects are looking forward to implement Innovative concepts regarding design, integration of materials and methods, structure, enclosure and mechanical systems.

Parallel to this, they expect to add an outstanding contribution to construction technologies and building processes, operation and maintenance.

Advancements in the disciplines of architecture, urban and landscape design, civil, urban and environmental engineering, and other fields involved in the production of the built environment in an excellent way.

As all the other construction projects, sustainable construction projects also use a long-term monitoring methods to evaluate whether expectations and goals have been met while distributing knowledge, including project documentation, communication, education and training.

##### *II. Ethical standards and social presence – Community*

In accordance with all three project stakeholders, "Projects must adhere to the highest ethical standards and promote social inclusion at all stages of construction, from planning and building to use and servicing; to ensure an enduring positive impact on communities". Therefore, Proposals must demonstrate how they enhance the collective realm.

In this scenario, sustainable construction projects should adhere to ethical standards in all phases of the project. Contributions to the formation of socially-viable environments, strengthening of shared values and empowerment of communities is another risk that sustainable construction projects want to address in the field.

In order to maintain a single unit among the participation of stakeholders, including users, clients, neighborhood affiliations, local authorities and non-governmental organizations, these projects must fairly engage with all the parties with respect to all types of works.

Quality of working conditions in the construction industry and including on site; with specific attention given to fair compensation, adequate benefits, safety and gender equality.

Political transparency, unbiased processes and commitment to principled interaction, just practices, all in the effort to prevent corruption at every level is another factor that falls in to the category of people.

##### *III. Resource and environmental behaviour – Globe*

Also, in project C, the general manager thoroughly emphasized that, "in this sustainable construction projects, they must exhibit a sensible use and management of

natural resources throughout their entire life cycle". Moreover, "long-term environmental concerns, especially pertaining to stocks and flows of material and energy, should be an integral part of the design philosophy".

In accordance with enhancing the environmental performance, minimizing the project's ecological footprint and maximizing its positive impact on the environment is highly considerable risk factor.

Another issue of a sustainable construction project is environmentally-conscious land use strategies and policies that preserve the natural landscape, while taking water and land reclamation into account.

Use of renewable energy in construction to reduce CO<sub>2</sub> emissions and avoid toxicity is also a must with regards to the sustainable standards of the Sri Lankan context.

Innovative deployment of material resources in construction with an emphasis on cradle to cradle cycles, mining existing building stocks and reduction of waste is currently emerging in all sustainable construction projects as there is no proper way of construction waste which eliminate the harmful effects to the environment.

Resilient products, robust construction details, smart interaction of building systems and environmentally sound technologies are to be developed with the intention of providing a standard technological methods of construction.

#### IV. *Economic feasibility and compatibility – Success*

In the economical perspective, the system manager in organization C brought out that, "Projects must prove to be economically feasible with regard to channelling and managing financial flows, promoting an economy of means and be compatible with demands across the construction's lifespan".

Basically, funding sources and profits earned must be legitimate and transparent in all types of projects while they should cover operating costs over their lifetime and generate an acceptable rate of return.

Integration of the project into the wider economic framework of local, regional, and global monetary flows are also properly managed in order to move the project towards sustainability.

As per the current laws and regulations of the country. A coherent plan is needed to demonstrate flexibility to adapt future changes of user needs, ownership, laws, regulations, and economic fluctuations.

#### V. *Background and aesthetic influence – Place*

With regards to the contextual and aesthetic impacts, green consultant in project A, emerged the point that, "Projects must convey a high standard of architectural quality as a prevalent form of cultural expression". With space, form and aesthetic impact of utmost significance,

the material manifestation of the design must make a positive and lasting contribution to the physical, human and cultural environment.

Therefore, an improvement of existing contextual conditions responding to the natural and built environment is needed with interdependencies of landscape, infrastructure, urban fabric and architecture.

While working with the given building stock through sensitive restoration, re-use or re-modeling of the built environment is much more needed in sustainable projects.

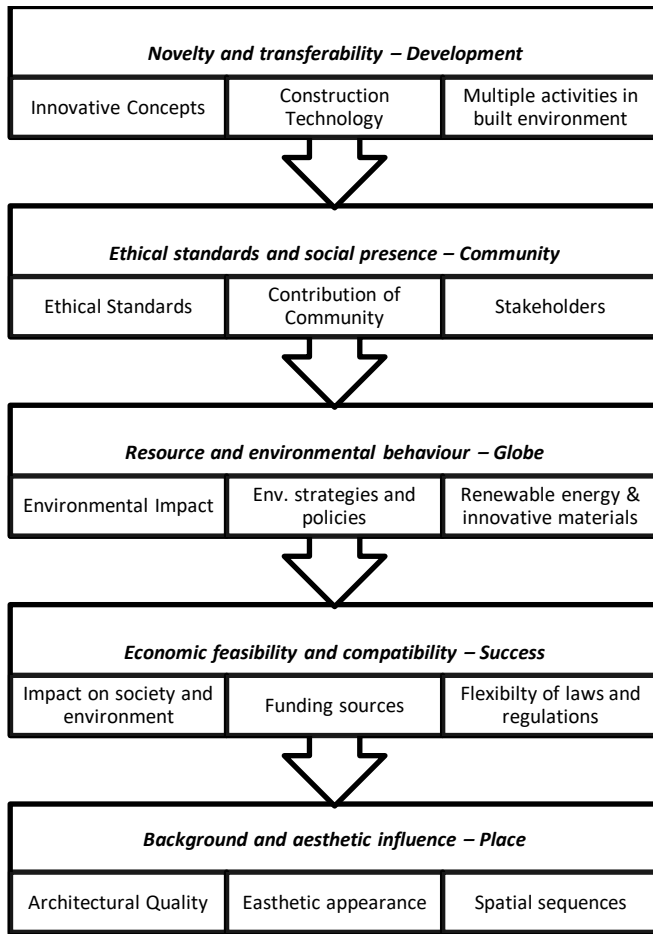
Inventive programming strategies in terms of use, multiplicity of functions, short-term flexibility and long-term adaptability also highly considerable since, architectural quality and aesthetic impact, specifically concerning space, spatial sequences, movement, tactility of materials, light and ambiance are the main targeted factors in this sustainable construction projects.

## IV. DISCUSSION AND CONCLUSION

Sustainable construction is rapidly expanding with the continued development of green codes and eco-friendly building materials. As a result, sustainable construction now has been woven into the fabric of nearly all the services offered by contractors.

Risks are considered as implications of uncertainties, with possible both positive and negative impacts on project goals. Also, stakeholder perception is examined of how much the sustainable and traditional project delivery achievement is influenced by different stakeholders.

Results reveal that sustainable construction projects are basically facing five (5) types of risks than the traditional construction projects; Innovation and transferability – Development, Ethical standards and social inclusion – Community, Resource and environmental performance – Globe, Economic viability and compatibility – Success and Contextual and aesthetic impact – Place.



Undertaking the above case study survey, risks which are pertaining to the sustainable construction projects can be summarised as the depicted framework.

By following each and every factor of the framework, all the identified risk factors can be eliminated from the sustainable construction projects whilst incorporating with elements of economic efficiency, environmental performance and social responsibility – and contributes to the greatest extent when architectural quality, technical innovation and transferability are included.

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ACKNOWLEDGMENT

This research was supported by the Green Building Council of Sri Lanka and special thanks goes to the completed and on-going construction projects with the concept of sustainability with the intention of having a better future in construction industry for providing the necessary information to undertake this research in an effective way.