MANAGEMENT OF ENVIRONMENTAL RISK FACTORS IN HIGHWAY CONSTRUCTION PROJECTS IN SRI LANKA WITH CONTRACTOR'S PERSPECTIVE

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Dissertation submitted in partial fulfillment of the requirements for the degree Master of Science in Project Management

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DECLARATION

I declare that this research is my own work to the best of my knowledge and it does not contain any materials of previously submitted dissertations prepared by researchers of other universities, institutes or higher education centers. Further, previously written and published materials are not included without providing relevant citation and references in text

Further I admire and acknowledge the immense contribution of my research supervisor Ch.QS Prof. (Mrs.) B.A.K.S. Perera towards the successful completion of the research. I confirm that I will never publish any articles or any other publication based on this research without mentioning the name of research supervisor as co-author of this research if I have not obtained any written consent to do so.

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K.I.L. Abhayantha Date

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19.06.2022

Ch.QS Prof. (Mrs.) B.A.K.S. Perera Date

ABSTRACT

Management of environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective

Environmental risk factors are vital in highway projects and it has become a crucial issue in Sri Lanka. The contractor is the main contracting party who suffers due to those environmental risk factors. Thus, it is very important to investigate how to manage the environmental risk factors in highway construction projects in Sri Lanka with the contractor's perspective. Accordingly, this research aimed at investigating how to manage environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective. The mixed approach was used for the study and initially a literature review was conducted in relation with highway construction projects in Sri Lanka. Then, a semi structured expert interviews were conducted to validate the findings to the Sri Lankan highway projects and analyzed with the use of manual content analysis. Finally, two rounds of questionnaire survey were conducted and analyzed collected data using statistical methods.

37 environmental risk factors were identified in highway construction projects in Sri Lanka with the contractor's perspective and out of them, 11 risk factors were identified as the most significant environmental risk factors. According to the analysis "Natural resources depletion in Sri Lanka like soil, sand, aggregate etc." has selected as the most significant risk factor by contractors. To manage above identified significant risk factors 24 most suitable risk response measures were selected. 13 out of them are common risk response measures and rest of the others were unique solutions for specific risk factors. At the same time environmental risk factors were mainly allocated to contractors in highway construction projects in Sri Lanka as per the perspective of the contractors. Finally, the recommendations were given to use of most suitable risk response measures in a meaningful way in highway construction projects to manage the environmental risk factors using the framework.

Keywords*: Highway construction projects, Environmental risk factors, Contractor, Risk allocation, Risk response measures*

DEDICATION

To my family members for giving me great support and great encouraged for me to do further studies……

Special thanks should goes to my supervisor who has given immense support and guidance for the successful completion of my research……

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K.I.L. Abhayantha

19 June 2022

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ABBREVIATIONS

RDA	–	Road Development Authority
USD	–	United Sate Dollars (Money)
APM	–	Association for Project Management
PMBOK	–	Project Management Body of Knowledge
PLC	–	Project Life Cycle
EPD	–	Environmental Protection Department
PERT	–	Program Evaluation and Review Technology
PMI	–	Project Management Institute
RMP	–	Risk Management Plan
ADB	–	Asian Development Bank
EIA	–	Environmental Impact Assessment
ESD	–	Ecological Sustainable Development
EMP	–	Environmental Management Plan’
RTR	–	Risk Transfer
RAV	–	Risk Avoid
RAC	–	Risk Acceptance
RMI	–	Risk Mitigation
MWR	–	Mean Weighted Rate
SI	–	Significant Impact
GSMB	–	Geological Survey and Mining Bureau
NBRO	–	National Building Research Organization

1. INTRODUCTION CHAPTER 1

1.1 Background

Construction projects are highly complex and risky due to the involvement of various activities (Abd Karim, Rahman, Memmon, Jamil, & Aziz, 2012; El-Sayegh & Mansour, 2015; Jayasudha & Vidivelli, 2016; Yoon, Tamer, & Hastak, 2015). While engaged in construction projects, contractors face numerous risks such as environmental impacts, financial issues, time & cost overruns, political, regulatory or economic factors and procurement issues (Ayyub, 2003; Karlson & Mortberg, 2015; Lee & Schaufelberger, 2014; Mann, Anees, Rankavat, & Joshi, 2021). According to the author's view, the project risk can be defined in different manners. It can give positive and negative influences related to project objectives (Adedokun, Ogunsemi, Aje, Awodele, & Dairo, 2013; Badalpur, & Nurbakhsh, 2021; El-Sayegh, & Mansour, 2015). As per Dey and Ogunlana (2004) and Rostami and Oduoza (2017), causes of risk differ with immenseness of the project, complexity of the organisation, rapidity of construction, location and appropriateness of technology. When discussing about risks, besides the complexity of a project, the Project managers should focus their attention on the other parameters like social, environmental, safety, security, as well as inside and outside stakeholders (Fang & Marle, 2012). It is very difficult to control and manage all the risks at once since it is a waste of time. Thus, it is better to identify the most critical risks and find out the strategies to manage those (El-Sayegh & Mansour, 2015).

Risk management is essential in construction projects (Moshood, Adeleke, Nawanir, & Mahmud, 2020; Tran & Molenaar, 2014). As prescribed by Douglas (2009), as well as emphasized by Yoon et al. (2015), management of risk involves in identifying, assessing and prioritizing risks through monitoring, controlling and applying the resources for the better achievement of the project objectives. At the same time, it is defined as analysing, identifying and responding to the related risk factors enabling to achieve the expected goals (Project Management Institute (PMI), 2013). Zhang and Fan (2014) confirmed that after identifying the risk factors, they can be removed or controlled by dint of relevant response strategies. The proper management of risk in a systematic way is the foundation of a successful project. It

is indeed understood that level of project success and count of risk management effort has better relationship (Bahamid & Doh, 2017; Elkington & Smallman, 2002; Goh & Abdul-Rahaman, 2013). Further, it was emphasized that to manage the construction projects in a successful manner, it is required to achieve the following goals such as time, cost, quality, safety and environmental (Mhetre, Wagh, Bhujbal, Patil. & Ranaware, 2019) and they must achieve within the given boundaries (El-Sayegh & Mansour, 2015). Meanwhile, Rahimi, Tavakkoli-Moghaddam, Iranmanesh, and Vaez-Alaei (2018) have emphasized that the risk management process directly deal with the maximization of the occurrence of main objectives of the project due to positive events while the minimization of the above due to negative events. At the same time, first step of risk management is the risk identification while the risk classification is one of the important processes of risk identification (Perera, Dhanasinghe, & Rameezdeen, 2009).

Several authors have classified several main risk types which affect the construction industry. They are financial risks, technological risks, social risks and environmental risks (Ahmadi, Behzadian, Ardeshir, & Kapelan, 2017; Alamigir et al., 2017; Jayasudha & Vidivelli, 2016; Laurance et al., 2014). Further, the project risks can be categorized as known and unknown risks (Bahamid & Doh, 2017). It is easy to identify, analyse, plan and prepare responses for the known risk while it is difficult to find solutions for the unknown risks (Crnkovic & Vukomanovic, 2016). As per the past studies done in globally the environmental risks are more critical (Coffin, 2007). Further, when comparing with all other risk factors, environmental risk factors are directly caused for the drawbacks of the road construction projects (Coffin, 2007; Creedy, Skitmore, & Wong, 2010; Laurance, Sloan, Weng, & Sayer, 2015).

The requirement of road expansions have been increasing rapidly and in 2050 it will be expected an addition of 25 million km paved roads globally. USD 70 trillion funds are required for the G20 industrial nations in 2030 for the construction of new roads and other infrastructure (Alamgir et al., 2017; Dulac, 2013; Laurance et al., 2014). Because of the higher investment in capital, higher complexity and the challenges of economic, social, as well as political, the highway construction

projects are very risky and involved with high uncertainty with comparison to other construction projects (Ahmadi et al., 2017; Molenaar & Wilson, 2009).

As discussed above, since highway construction projects are involved with high risk due to environmental issues, it is better to discuss the ways to minimize such risks (Alamgir et al., 2017; Coffin, 2007; Laurance et al., 2014). Further, various environmental (Laurance et al., 2015), economical and socio- political (Collier, Kirchberger, & Sonderbom, 2016) issues are created due to poor planning or execution of the road construction projects. Due to road construction projects, the biodiversity has been affected throughout the whole construction period and it can also be affected due to human activities after the construction period (Alamgir et al., 2017; Laurance, Goosem, & Laurance, 2009; Trombulak & Frissell, 2000). In addition, roads are like barriers to the animal movements and sometimes animals are not willing to return to their territory due to above barriers. (Alamgir et al., 2017; Laurance & Gomez, 2005). Further, it has identified air and water pollution are the most critical environmental risk factors in road construction projects (Coffin, 2007). At the same time, Chen, Li, and Wong (2000), Walimuni, Samaraweera, and Silva (2017) and Zou and Zhang (2009) emphasized that dust, harmful gases, noises as well as solid and liquid waste as the major types of environmental risks in road projects. Hence, it is necessary to identify and mitigate all the environmental issues in road and highway construction projects.

1.2 Problem statement

As per the studies done in Sri Lanka, it has identified that most of the road projects are seriously affected due to high risks and it also emphasized that only limited studies have been done in Sri Lanka in relation with risks (Perera et al., 2009; Perera, Rameezdeen, Chileshe, & Hosseini, 2014). As specified in “background” it is identified that environmental risks are the most critical in all over the world in highway construction projects (Ahmadi et al., 2017; Alamgir et al., 2017). Since most of the Sri Lankan highway construction projects govern with foreign funds it is Sri Lankan government’s responsibility to properly utilize the foreign funds in a valuable manner and achieved the required time, cost and quality targets. Further, the Road Development Authority (RDA) has already completed 277 km highway

roads and plan to complete 241.8 km of highway roads within next five years (RDA, 2020).

As per past studies, some researchers have identified risk management in road construction in general (Diab, Varma, & Panthi, 2017; Shayan, Pyung Kim, & Tam, 2019). Some researchers have identified management of financial risk factors in road sector (Kagne & Vyas, 2020; Nguyen, Mollik, Chih, & Asce, 2018). Further, there are very few researches done in globally considering environmental risk management in highway construction projects. Especially, when focused to Sri Lanka it is hard to find literature in relation with above matter. At the same time, the risk management process differs from project to project and country to country. Therefore, considering the above industrial need and the literature gap, it is important to conduct a research on "Management of environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective".

1.3 Aim of the Study

To investigate how to manage environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective.

1.4 Objectives of the study

- Identify the environmental risk factors related to highway construction projects
- Evaluate the most significant environmental risk factors in highway construction projects considering contractor's perspective
- To propose the most suitable risk response strategies/ response measures to manage above identified most significant environmental risk factors
- Analyse the allocation of significant environmental risks factors
- To develop a framework to manage environmental risk factors in Sri Lanka with contractor's perspective

1.5 Scope and limitations

This study was totally focused on the EPC foreign funded new highway construction projects in Sri Lanka from the perspective of contractors. Rehabilitation of highway construction projects were not considered.

1.6 Research methodology

1.6.1 Literature review

With the help of the comprehensive literature review using journals, books, conference papers and research papers as well as web sites the environmental risk factors and the management strategies were identified.

1.6.2 Semi structured interview

Semi structured interviews were conducted with the view point of 10 expertise who work with contractor's organization having more than 10 years working experience in construction industry and having more than 5 years working experience in highway construction projects and analysed the collected data using manual content analysis. Accordingly, it was expected to identify how the contractor suffers with the environmental risk specific to Sri Lanka and specific to road sector and how to validate the strategies and related risk measures which found throughout the literature review for Sri Lankan highway construction projects.

1.6.3 Questionnaire survey

After a comprehensive study of the mastery viewpoints of the expertise about the risk factors at the semi structured interviews, a questionnaire was prepared, based on the collected data to yield the validity of the study to the Sri Lankan context. Furthermore all the risk factors were ranked to identify the significance of environmental risk factors. Not only that but also, the steps have been taken to identify and to propose suitable risk response strategies as well as related response measures to manage above selected environmental risk factors which faced by the contracting parties.

1.7 Chapter breakdown

Chapter 1: Introduction

This consists of an outline of the research with the problem statement, aim and objectives, scope and limitations as well as research methodology.

Chapter 2: Literature review

This consists of review of comprehensive literature on "Management of environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective".

Chapter 3: Research methodology

This consists of outline of the research methods and explain the possible methods which can be used for data collection as well as data analysis.

Chapter 4: Research findings and data analysis

This consists of findings from expert interviews as well as questionnaire survey related to research topic and comprehensive analysis of information in detail.

Chapter 5: Conclusion and recommendation

This consists of providing conclusion and recommendation as well as limitations related with this research.

2. LITERATURE REVIEW CHAPTER 2

2.1 Introduction

Chapter 1, highlighted the importance of the research topic as well as the requirement of conducting the research. The chapter 2 consists of comprehensive literature review describing the validity of the risk management process in highway construction projects as well as how it helps to get the decisions.

This chapter discusses the risk and uncertainty in the construction industry and how the construction field affected due to environmental risks. Further, it was discussed about construction field commonly and then narrows down to highway construction projects in Sri Lanka with contractor's perspective. Accordingly, this chapter is discussed how the highway construction projects are affected due to environmental risks factors.

2.2 What is a risk and uncertainty?

Risk has relationship between loss/gain of the event as well as effects on risk and uncertainty affects objectives of the project either positive or negatively (Gain, Kumar Mishra, & Aithal, 2022; Iqbal, Choudhry, Holschemacher, Ali, & Tamosaitiene, 2015; Issa, Marouf, & Faheem, 2021). By just over looking, it cannot get decision about risks. But it can be minimized, controlled, shifted, distributed or adopt (Taroun, 2014). Dey and Ogunlana (2004), have stated that entire human attempts were involved with risk and the failure or success of any project depends on how we tackle and handle it. Therefore, the risk and uncertainty is available in everywhere in each and every construction projects all over the world whether it is small or large scale. Mainly, the risks are directly affecting the project's main objectives such as time, cost, quality subjective with how it handled (Bahamid & Doh, 2017; PMI, 2017). Accordingly to successfully complete the project via achieving the required targets and objectives, it is required to manage the risks in controllable manner (Sharma & Gupta, 2019). Construction projects have unique features like long projects periods, complexity, and financially instability as well as uncontrollable construction environment. Hence not like other industries, the construction industry is having numerous risks which are not easy to control (Taylon, Bafail, Abdulaal, & Kabli, 2014).

2.3 Risks in construction industry

The construction works have to be carried out in a complicated environment and hence, risks are ineluctable in construction field (Akintoye & MacLeod, 1997; Sharma & Gupta, 2019). According to Rajput, Agarwal and Yadav (2020), confirmed that highway construction projects are also consist with numerous risks. Various authors identified that the construction projects are impacted or affected due to risk. The above effects can be elaborated in many ways, such as: losses of financial; damages to property; injuries to people, failure to obtain the approval for documents as per local authorities and legal requirements as well as effects of all above (Abassi, Abdel-Jaber, & Abu-khajedart, 2005; Gain, Kumar Mishra, & Aithal, 2022). Further to Kumar, Sheikh and Asadi (2017) and Mills (2001), performance of the project, quality, potential, capacity and finance situation can be changed due to involvement of risk. The risk can be occurred at any stage and they can be categorized as project specific or non-project specific risks (Creedy, 2006; Gain, Mishra, & Aithal, 2022). The aim and importance of this study is to identify risk involved in construction projects in early stage (beginning) of the project and manage it with providing minimum negative effect on project targets as well as maximum positive results (Sharma & Gupta, 2019).

It is better to handle major risks as it is not easy to control all possible risks in construction project (El-Sayegh, 2008; El-Sayegh & Mansour, 2015). Siraj and Fayek (2019) simplify risks in the construction industry in a common way and categorized and ordered those as specified below; environmental, management, construction and resource-related, technical, contractual & legal, economic & financial, social, political, site conditions and health-safety. All construction related activities carried out in complex work environment and later on it will cause for major risks in all over the world (Olamiwale, 2014; Renault & Agumba, 2016).

Edward and Bowen (1998) and Mishra and Malik (2017) identify risk management is as very convenient instrument to handle the risks in construction projects as well as manage and control deliverables throughout project life cycle. By considering the above scenarios, risk management provides guidance for a better achievement of the construction projects and it is the very important tool to manage the risks in

construction industry as well as it provides guidance for failure or success of the construction projects (Hwang, Zhao, & Toh, 2014; Moshood, Adeleke, Nawanir, & Mahamud, 2020).

2.4 Risk management in construction industry

Risk management provides a proper method of reduction the risks encountered in the construction industry as it provides an organized way of assigning risk to construction projects (Olamiwale, 2014). In essence, risk management is vital for the effective identification and proper control of risk. Effective risk management means proactively handle any likely future occurrences of risks (Renault, & Agumba, 2016). Using risk management, it can increase the possibility in occurrence of positive risk and decrease the possibility in occurrence of adverse risks as well as risk has positive or negative impact on project objectives (Badalpur & Nurbakhsh, 2021; Klemetti, 2006; Sharma & Gupta, 2019). Further, the decision makers can understand and use the risk management for the preparation of required plan as well as prevention of disasters and reduce the impact of the risks. As concluded by Jayasudha and Vidivelli (2016) to enhance the profitability as well as to minimize the losses in the activities of construction, the risk management is very essential. Accordingly, this process provides guideline to minimize the risks and achieve business goals via analyzing the risks and making the decisions to get appropriate course of actions (Liu, 2010; Moshood, Adeleke, Nawanir, & Mahmud, 2020).

Serpella, Ferrada, Howard, and Rubio (2014) identified that to enhance the risk management in productive manner, it is essential to use the best methodology, communication and further, it is required better experience in the same field. There are two types of risks available in construction field. Those are acceptable and unacceptable. An acceptable risk can negatively affects for the task on the non-critical path and unacceptable risk can negatively affects the critical path in construction industry (Jayasudha & Vidivelli, 2016).

As observed by Jarkas and Haupt (2015) construction risk management decisions are mainly taken according to construction manager's early experience, intuition as well as professional judgment. Also, risk management is combined with all other management areas of a project and it is crucially supported for the success of the

construction project (Moshood, Adeleke, Nawanir, & Mahmud, 2020). Adeleke, Bamgbade, Salimon, and Lee (2019), discovered that policy as well as rules and regulations of government act a crucial part to balance the combination with risk management and organizational factors.

Boateng, Ahiaga-Dagbui, Chen, and Ogunlana (2015) emphasized that, risks should be identified during different stages of the projects. Hence, authors have further revealed that risk management is an ongoing and iterative process. Badalpur and Nurbakhsh (2021) and Tserng, Yin, Dzeng, Wou, Tsai, and Chen (2009) has also agreed the above argument that risk management must be conducted throughout the life cycle of the construction project from the initial stage up to commissioning of the project, with achieving the project objectives in terms of time, cost, quality, safety, and environmental sustainability (Han, Kim, Kim, & Jang, 2008; Saleem, Sajid, Aftab, & Malik, 2021; Sharma & Gupta, 2019). By reviewing these perspectives, project risk management is a crucial part in decision making in construction projects which determines the success or failure of those projects (Moshood, Adeleke, Nawanir, & Mahmud, 2020). At the same time Rajput, Agarwal, and Yadav (2020), specified that highway construction projects consist with numerous risks and it is crucial to include risk management in the project plans.

Further to Perera, et al. (2014), Sharma and Gupta (2019) and Uher and Toakley (1999), the aim of the risk management process is to control the level of risks and modifying the related effects as well as to deal with better way. Hence, it requires to further study on Risk management process and will be discussed in next.

2.5 Risk management process in construction projects

Gain, Mishra, and Aithal (2022), Liu, Li, Lin, and Nguyen (2007) and Yoon et al. (2015) specified that project risk management is a systematic process to control risks on construction projects and can be categorized to two main phases such as risk assessment and risk control. Further to their elaboration, several steps comes under risk assessment such as identification of risks which affect the projects, risk analysis in terms of prioritizing risks by assessing their probability and impact. At the same time the other steps comes under risk control, such as management plan, resolution, monitoring as well as development of risk response strategies to reduce the impact

of the risks. As explained by Sharma and Gupta (2019), Identification, Classification, Assessment and Response to the risk are main stages in the process of risk management. Out of which, risk identification and assessment are prominent risk management steps. Further to Association for Project Management (APM, 2000) and Mishra and Malik (2017), specified that, it covers the process of identification, assessment, allocation, and management of all project risks.

For implemented procedures to be effective, contractors and organizations have to target the root cause of the risk and Moshood, Adeleke, Nawanir, and Mahmud (2020) reveled that selection of risk management procedures should be focused on keeping risk at an acceptable level. In addition to that, Douglas (2009) stated that the process of risk management consist with monitoring, controlling and applying managerial resources with a proper coordination and economically efficient manner in order to minimize the probability and/or impact of unfortunate events and so as to maximize the realization of project objectives. While referring to the literature so many authors elaborate the risk management process in to several phases (Dhanasinghe & Perera, 2008; Hellstan, 2018).

Further the following table illustrates the phases (steps) identified by the several authors in relation with risk management process (Table 2.1).

Table 2.1 Phases (Steps) of Risk management

Phases of Risks Management	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Risk Identification	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Risk classification		√		√		√											
Risk assessment	√	√				√		√	√								
Risk allocation	√																
Risk management	√									√							
Risk Response		√	√	√	√	√		√		√	√		√	√	√	√	√
Risk Analyzing			√	√	√					√	√	√	√	√	√	√	√
Risk Attitude				√													
Risk Evaluate							√										
Risk Control							√		√	√		√		√		√	
Risk Monitor/review								√	√	√	√		√	√	√	√	√
Risk mgt. and Planning											√						
Risk Plan												√					

Phases of Risks Management	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Risk Implementation												√					
Risk Exposure													√		√		
Risk Prioritization													√		√		
Risk Contingency plan													√		√		
System Approach													√		√		
Risk Cont. Reassessment													√		√		

'A - Renault and Agumba (2016), B - Zhi (1995), C - Bahamid and Doh (2017), D- Flanagan and Norman (1993), E - Perera et al. (2009), F - Sharma and Gupta (2019), G - Hellsten (2018), H - Karimi azari, Mousavi, Mousavi, and Hosseini (2011), I – Fok, Neo, Wen, and Veeresh (2012), J- PMI (2008), K - Barkley (2017), L – Chen, Dong, Zhang, Peng, Fang, and Li (2020), M - Kululanga and Kuotcha, (2010), N - Dako (2019), O - Wang and Chou (2003), P - Naji and Ali (2017), Q – Walker and Johannes (2003)

Once, over view the Table 2.1, it is showing that maximum number of responses given for the "**risk identification**" phase and it is the first and most important phase in the risk management process. As per the above Table the "**risk classification**" phase has not much highlighted. But, Rezakhani (2012) confirmed that through risk classification, the researchers can identified most important risk factors to be considered under the risk management plan. Accordingly, the author has identified that this phase should be included in the research.

Further to that "**risk analysis**" is the next highly responded phase in this process. According to El-Sayegh and Mansour (2015), "**risk analysis**" is helped to critically evaluate the relevant risks, arranged risks in an order with the level of importance and allow the management to select priority risks. In addition, Badalpur and Nurbakhsh (2021) and Karimi Azari et al. (2011) recognized that Risk analysis as the key factor and most tasking procedure in managing risk. Further referring to the above Table, "**risk response**" is one of other important phase to be considered. It is prescribed as the acceptable mitigation steps of treating risk must be employed once the project risks have been known and analyzed. The last process is "Monitoring and controlling of the risks responses plan", and PMBOK (2013) mentioned the importance of examining the residual risks and identifying and assessing the potential risks and the efficiency of all evaluation during the project. Although, risk responses are carried out during the project life cycle (PLC) and the project must be continuously examine in such a way to detect new risks and manage possible changes (Martins, 2011; Tepeli, Taillandier, & Breysse, 2021). While "**risk**

monitoring" is continuous assessment and information about the risk (Szymanski, 2017) and the "**risk control**" does not seek to stop completely the source of the risk, action taken to reduce the risk present (Bahamid & Doh, 2017).

Considering above responses as well as the authors view, 4 phases (steps) are considered for the current research and considered as previously identified by Szymanski (2017) and Sharma (2013). The 1st phase (step) of risk management process is risk identification.

2.6 Risk identification

This is the initial step in the risk management process and it involves to determine all potentials risk that may occur within the project (Gain, Mishra, & Aithal, 2022; Perera et al., 2009; Renault, & Agumba, 2016; Tchankova, 2002). Risk identification is defined by various authors. As prescribed by Kuang (2011), if risk identification is critically performed, it ensures successful risk management as unknown sources of losses escalate into unmanageable occurrences with unforeseen outcomes. The purpose of risk identification is to evaluate potential risks and its' consequences on the project's ability to reach project targets (Sharma & Gupta, 2019). Zhang and Fan, (2014) defined risk identification as identifying and keeping records of the associated risks. Similarly, Bahamid and Doh, (2017) risk identification can be defined as the process of analytically and constantly identifying, assessing and categorizing the initial importance of the risks related to construction projects (Bahamid & Doh, 2017). Additionally, Liu, Zhao, and Yan (2016) stated that and the interrelationships among these risks should be concerned.

As per the perspectives of Arunplod (2019), Hillson (2002) and Sharma and Gupta (2019), under risk identification, it is required to consider positive as well as negative risks. More to then, Kuang (2011) identified that the effect of the non-identification of positive risks equates to the effect of non-identification of negative risks.

A part from that, Sharma and Gupta (2019) specified various risk identification techniques as questionnaire surveys, literature review, checklist, documentation review, brainstorming, delphi technique, case studies of past projects. However, Sharma and Gupta (2019) and Zou, Zhang, and Wang (2007) were ranked the key

risks based on their effect on the project objectives in terms of environment, cost-overrun, time-delays, quality issues, safety with referring to the construction projects in China.

Risk classification is an important step in the risk identification process, in order to structure the diverse risks that may affect a project (Rezakhani, 2012). Hence, the risk classification step will be discussed in next.

2.6.1 Risk classification

Renault and Agumba (2016) and Tah and Carr (2000), classified project risks and divided them into internal and external risks. Internal risks are those which are related to the management of internal resources of the project, while external risks are prevalent in the external environment of the project (Sharma, 2013; Violante, Dominguez, & Paiva, 2018). Further to El-Sayegh (2008) and Violante, Dominguez, and Paiva (2018), defined internal risks as those that are project-related and usually fall under the control of the project management team, while external risks are those that are beyond the control of the project management team. Among the internal and external risks, it is required to identify them to control or mitigate as well as if identified at the initial stage of the project, the controllable risks can be eliminated using the appropriate technique while the uncontrollable risks require continuous monitoring and cannot be eliminated without using any mitigation techniques (Renault & Agumba, 2016; Schatteman, Herroelen, Van de Vonder, & Boone, 2008).

Construction risks are classified in many ways by risk types (*i.e.*, natures, conditions and magnitudes, etc.), the sources, origins, project phase and not achieving required standards, regulations and qualities (Cooper & Chapman, 1987; Edwards & Bowen, 1998; Gain, Mishra, & Aithal, 2022; Klemetti, 2006; Zhou, Vasconcelos, & Nunes, 2008). Further as tabulated by Bahamid and Doh (2017), several authors classified risk in to following phases. Enhassi and Mosa (2015) has divided risk in to legal, physical, design, political, financial, environmental, logistic, management and construction. At the same time Kuo and Lu (2013) classified phases of risk such as construction safety related, construction management, engineering design, natural hazard, socio, and economic. In addition to that Violante, Dominguez, and Paiva

(2018) have classified risks of construction in to 7 main phases; internal, construction and execution, planning/ project, administrative and financial, safety, technical quality and environmental.

Moreover there were number of authors identified risks in to below classifications and accordingly tabulated them as specified in Table 2.2. Those are the most identified phases of risks categories through the literature review by various authors which were affected for the construction projects.

Table 2.2 Risk classification

Classification of Risks	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Environmental	√		√	√		√	√	√	√	√	√	√	√	√	√	√	√
Political	√			√	√	√	√	√	√	√	√	√	√		√	√	
Legal	√			√	√	√		√						√	√	√	
Financial	√			√				√			√		√	√	√		
Management	√			√		√							√	√		√	
Design	√			√									√	√		√	
Construction	√					√							√	√	√		
Cultural	√			√						√					√	√	
Social					√	√			√		√	√					
Financial and Economic					√	√						√			√		
Internal		√					√					√					
External		√					√					√					
Economic								√	√	√	√						√
Technical					√	√	√										
Physical	√			√									√				
Logistic	√			√									√				
Safety			√			√											
Quality			√														
Cost overrun			√														
Time delays			√														
Resource related						√											
Contractual						√					√						
Site Condition						√	√										
Commercial							√										
Socioeconomic							√										
Geographical										√					√		
Operation											√					√	
Technology											√					√	

Classification of Risks	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Architectural				√													
Product															√		
Geotechnical															√		
Communication risk															√		
Engineering risk											√						
Insurance risk											√						
Socio Political																	√

'A - Renault and Agumba (2016), B - Zhi (1995), C – Zou et al. (2007), D - Kishan, Bhatt, and Bhavsar (2014), E - Ameyaw and Chan (2015), F – Hardcastle, Edwards, Akintoye,, and Li (2005), G - El-sayegh and Mansour (2015), H – Lee and Schaufelberger (2014), I - Neilson (2006), J – Rostami and Oduoza (2017), K - Jayasudha and Vidivelli (2016), L – Yoon et al. (2015), M - Bahamid and Doh (2017), N -Baloi and Price (2003), O -Tadayon, Jaafar, and Nasri (2012), P - Thaheem and De Marco (2013), Q - Alamgir et al. (2017)

Referring to above Table 2.2, it is clearly understood that most of the authors have mainly classified risks in to environmental, political, Financial, legal groups and those are the most important risks to be minimized for the success of the projects. Further, most of the authors have identified that construction projects are affected due to environmental risk, but limited number of researches/ documents available in relation with above topic. Hence, it is better to discuss how to minimise the environmental risks in construction projects.

2.7 Environmental risk factors

As per Environmental Protection Department (1999), Uher (1999) and Walimuni, et al. (2017), construction activities are one of the major significant contributors to the environmental impacts which can be classified as air pollution, waste pollution, noise pollution and water pollution. Further, Ametepey and Anash (2014) and Uher (1999) emphasized that these impacts on the environment occurred due to wide range of off-site, onsite and operational activities. In detail, off-site activities are related with mining, manufacturing and transportation of materials and components, land acquisition and project design whereas, on-site construction activities are the results generated out of the construction activity for instances, air pollution, water pollution, traffic problems, and the generation of construction wastage. Jayasudha and Vidivelli, (2016) identified that environmental risk has the maximum risk rating out of the other risk factors. Accordingly, the environmental risk is the one of main key risk factors and it is required to address the environment risks for the better

achievement and success of the construction projects. Referring to the previous literature authors have identified the environmental risk factors in road and highway construction projects as specified below in Table 2.3.

Table 2.3 Environmental risk factors identified by past researches in road construction/ highway construction projects

Risk Factors	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Air and water Pollution				√		√	√					√			
Adverse weather conditions		√	√		√	√									
Introduction of chemical pollution							√	√	√			√			
Noise and other atmospheric effects							√			√		√			
Road related mortality								√	√	√					
Barrier effect								√		√	√				
Exotic species invasions								√	√		√				
Disruption of physical environment									√	√	√				
Road edges and road effect zone							√	√							
Physical and biotic edge effects										√	√				
Ecological damage				√					√						
Floods, earthquakes, etc.		√				√									
Human invasions								√		√					
Modification of animal behavior									√		√				
Contamination of Land	√		√												
Releases to air	√														
Releases to water	√														
Waste management and Disposal	√														
Impact on local Communities	√														
Use of raw materials and natural resources	√														
Ecological Conservation	√														
Heritage Conservation	√														
Emergencies	√														
Ecologically sustainable development (ESD)	√														
Difficulty to access the site (very far)		√													
Perceived Environmental Impact of Project			√												
Compliance with law and regulation for environment issue				√											

Risk Factors	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Ground conditions and contaminant					√										
Site conditions					√										
Mortality and Barriers to wildlife movement							√								
Changes to hydrology and water quality							√								
Erosion and sediment transport							√								
Road as habitat corridor and conduit							√								
Landscape change and fragmentation							√								
Ecological road network theory							√								
Landslides in mountainous areas										√					
Land Pollution												√			
Dust												√			
Solid and Liquid waste												√			
Ground movements												√			
Interference with natural drainage patterns												√			
A - Maria-Sanchez (2004), B - Kishan, Bhavsar, and Bhatt (2014), C - El-Sayegh and Mansour (2015), D – Abd Karim et al. (2012), E- Chilshe and Yirenkyi-Fianko (2012), F- Abd El-Karim, Mosa El Nawawy, and Abdel-Alim (2017), G - Coffin (2007), H – Laurance et al. (2009), I - Trombulak and Frissell (2000), J - Alamgir et al. (2017), K - Laurance and Gomez (2005), L – Walimuni et al. (2017)															

As illustrated in above table, most common risk factors identified via risk classification in relation with environmental risk are air & water pollution (Abd Karim et al., 2012; Abd El-Karim et al., 2017; Coffin, 2007; Walimuni, et al., 2017), adverse weather conditions (Abd El-Karim et al., 2017; Chilshe & Yirenkyi-Fianko, 2012; El-Sayegh & Mansour, 2015; Kishan, Bhavsar, & Bhatt, 2014), introduction of chemical pollution (Coffin, 2007; Laurance et al., 2009; Trombulak & Frissell, 2000; Walimuni et al., 2017), noise & other atmospheric effects (Coffin, 2007; Alamigir et al., 2017; Walimuni, et al., 2017), road related mortality (Alamigir et al., 2017; Laurance et al., 2009; Trombulak & Frissell, 2000), barrier effect (Alamigir et al., 2017; Laurance et al., 2009; Laurance, & Gomez, 2005), Exotic species invasions (Laurance et al., 2009; Laurance, & Gomez, 2005; Trombulak & Frissell, 2000), and disruption of physical environment (Alamigir et al., 2017; Laurance & Gomez, 2005; Trombulak & Frissell, 2000).

Further to that, the next most important phase (step) to be discussed in the risk management process is risk analysis.

2.8 Risk analysis

Risk analysis is useful to measure the significance level of the risk factors (Al-Shibly, Louzi & Hiassat, 2013). In addition, Iqbal et al. (2015) simplify the usage as to measure the uncertainty or probability of their occurrence and the level of impact of the identified risk. As per the studies done by Rassol, Franck, Denys, and Halidou (2012) revealed that risks are usually assessed according to two fundamental characteristics, probability and impact. Thus, the severity of the risk can be predetermined. Hence, Iqbal et al. (2015), further mentioned this step as prominent in order to help decision making in construction industry which has higher susceptibility to risks. In order to estimate the degree of the potential impact of the risk, several tools and techniques are derived by scholars. Consequently, Al-Shibly et al. (2013) and Violante, Dominguez, and Paiva (2018) explored that risk analysis can be conducted either by qualitatively or quantitatively as mentioned in Figure 2.1.

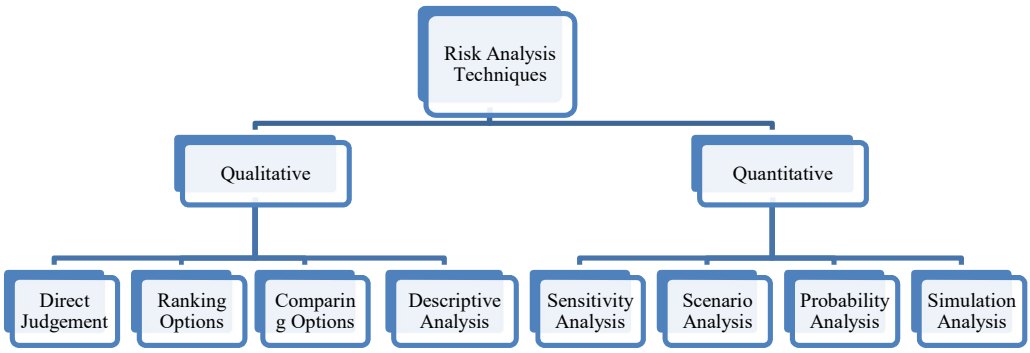

Figure 2.1 Risk analysis techniques

According to the above figure risk analysis techniques are classified in to main methods as qualitative analysis or quantitative analysis. This statistical approach has given more reliable interpretations based on some restrictive assumptions (Dzizdosz & Rejment, 2015). As described by Dzizdosz and Rejment (2015), Jepson, Kirytopoulos, and London (2020), Szymański (2017) analyzing techniques added multi-criterion decision making methods such as; PERT method, cost benefit analysis, decision tree methods & operational research and econometrics, fuzzy sets, neural networks as risk analysis techniques. Even though, the various analysis

methods are explored Jepson et al. (2020) discovered that qualitative techniques are highly used in construction industry. Besides, any technique is used to assess the risk that process should be ongoing and dynamic (Subramanyan, Sawant, & Bhatt, 2012). With the findings of the risk analysis, the risk response strategies can be formulated (Popvici, Fernando, & Navarrete, 2016) and will discuss in following sections.

2.9 Risk allocation

When discussing about risk management process, one of important phase to discuss is the risk allocation (El-Sayegh & Mansour, 2015). Dhanasinghe and Perera (2008) specified that proper risk allocation in construction contracts is considered as prominent, since risk identification and risk allocation are dominant factors in risk handling decisions. To handle risks properly, it is necessary to identify risks and properly allocate them. According to Bunni (1997), Bunani (2013), Perera et al. (2009) and Badalpur and Nurbakhsh (2021) when a risk has been identified, it should be assessed, analyzed, and allocated to various parties in order to keep them under control. Thus, it prevents the occurrence of harmful consequences. However, Andi (2006) argued that no risk can be eradicated consequently; the only option is to share, distribute or transfer the risks in the contractual documents. Any construction project shall carry out with the signing of a contract between owner and contractor. The objectives of a construction contract agreement are to allocate rights, duties, responsibilities and risks between the parties (Peckiene, Komarovska, & Ustinovicus, 2013). Further to Dhanasinghe and Perera, (2008) and Peckiene, Komarovaka, and Ustinovicius (2013), it is a fact that the employer allocates construction risks through contract clauses before the contract is awarded, and this facilitate contractors to have a clear understanding on risks they are allocated with.

According to the previous studies it has been identified that improper risk allocation may affect to the relationship between the client and contractor as well as may cause for the lower project performance (Zhang, Zhang, Gao, & Ding, 2016). Thompson and Perry (1992) as well as Perera, et al. (2009) suggest that a carefully drawn up contract will ensure the proper allocation of responsibilities same as the procedure which determines the type of contract and the tendering procedure for a project.

2.9.1 Risks allocation to contracting parties

El-Sayegh & Mansour, (2015) explained that allocating risks to the proper contracting party via either to owner, contractor or consultant. Further to explain, if risks are allocated to the consultant, then they are eventually allocated to the owner. At the same time, most prominent method to prevent risk is transfer risk to other contractual parties to handle risks successfully (Gain, Kumar Mishra, & Aithal, 2022; Wang & Chou, 2003). Further, it has elaborated that owners already allocate project risks through contract clauses in projects before the contract is awarded. Although, Tembo and Khatleli (2017) have mentioned that various mechanisms and processes are published in the existing literature and they are mostly developed for particular jurisdictions, project types and modes of procurement. Though concentrating the limiting factors of risk allocation is beneficial, the most of the studies concentrating on to whom the risk should be allocated, whether to the client or to the contractor.

Considering the previous research papers, following table (Table 2.4) indicates how the risk has allocated to contracting parties who engaged in the construction industry.

Table 2.4 Risk allocation to the contracting parties

Author	Client	Contractor	Consultant	Supplier	Sub-Contractor	Contracts	Designer	Govt. Agencies	External
A	√	√							
B	√	√	√						
C	√	√	√	√	√	√			
D	√	√							
E	√	√	√						
F	√	√		√	√		√	√	√
G	√	√	√						
H	√	√	√	√	√				
I	√	√	√						

A – Iqbal et al. (2015), B - Perera, et al. (2009), C - Al-Kharashi and Skitmore (2009), D - El-Sayegh and Mansour (2015), E – Chilshe and Yirenkyi-Fianko (2012), F – Wu, Nisar, Kapletia, and Prabhakar (2017), G - Dhanasinghe and Perera (2008), H – Al-Shibly, Louzi, and Hiassat (2013), I – Ashley, Molenaar, and Dickmann (2006); Ahmadi et al. (2017)

Referring to above Table 2.4 most of the authors have indicated the main risk allocated parties as the client, contractor and consultant.

Even though, risks are supposed to be managed effectively by the responsible parties Cooper, Grey, Raymond, and Walker (2005), Sharkey, Bell, Jocic, and Marginean (2014) and Waldron (2011) argued that risk is arbitrarily allocated to the stakeholders who do not have the best management capabilities. However, Yates, and Sashegyi (2001) recommended that the equitably and realistically sharing the risks among the project parties. In spite of that, El-Sayegh and Mansour (2015), Sharkey et al. (2014) and Waldron (2011) revealed that majority of risks are allocated for contractors, since they have performed the most tasks while completing projects, including technical, financial, legal, environmental and organizational responsibilities (Akintoye, Hardcastle, Beck, Chinyio, & Asenova, 2003; Perez, Gray, & Skirtmore, 2017). Hence, contractor attempts to add higher contingency amounts to their bid price in order to minimize their risk liability (Andi, 2006).

As per the research conducted by Yates and Sashegyi (2001) revealed that 91% of the respondents were passing down risks from client to contractor is an extensive practice along the construction projects. By reviewing above arguments, it can be emphasized that allocating the risk liability to contractor is the common practice in construction industry.

In order to address the risks, the suitable risk management strategies or risk response strategies are required to study. Therefore, types of risk response strategies will be discussed in next.

2.10 Risk response strategies

Tchankova (2002) mentioned that risk response is a fundamental component in the RMP that find out the action suits to address risks evaluated in the identification, qualification and quantification stages. Scholars have defined risk response in different ways. For instances, Olamiwale (2014) defined risk responses as the actions taken to eradicate, reduce or transfer a risk or its consequences. Similarly, the risk response refers to the identification, selection, evaluation and the actions to implement the project (Zhang & Fan, 2014). In addition, Turnbough (2005) determined a risk response as an alternative to eliminate or mitigate a projected risk and assign an optimum option as a response. According to the perspective of Nieto-

Morote and Ruz-Vila (2011) emphasized that responding to risks will enhance opportunities to achieve the project objectives since it is involved in developing options and/ or actions to the risks. This perspective was confirmed by Zhang and Fan (2014) mentioning as adapting to risk management process will improve the performance of the construction project management.

On the other hand, Renault and Agumba (2016) explained that appropriate risk response strategy should be developed subsequent to the risks identification and assessment. Authors have elaborated that properly designed risk plan is an integral part of the project plan.

According to Serpella et al. (2014), methods of risk response can be categorized as avoidance, reduction, retention, transferring, and sharing. Similarly, Albogamy and Dawood (2015) categorized risk response as; accept, transfer, reduce, defer and avoid. Further, Serpella et al. (2014) mentioned that the selection of a suitable risk response strategy will depend on the probability and outcome of the risk. As specified by University of Vermont (2012) revealed that commonly used risk response strategies by construction managers are accept, ignore, avoid, exploit, share, mitigate, diminish, reserve and communication and those were confirmed by Popovici, Fernando, and Navarrete (2016). Further Castelblanco, Guevara, Mesa, and Flores (2020), Flanagan and Norman (1993) and Perera, et al. (2009), simplified that risk can be managed either by sharing, distributing, transferring it to another party or by retaining it.

Considering all above facts following risk response strategies are selected for this study.

- Risk transfer
- Risk avoidance
- Risk acceptance (retention)
- Risk mitigation (reduction)

2.10.1 Risks transfer

Risk transfer means allocating risk responsibilities to other contracting parties. For example, in construction industry a contractor can transfer the risk to the

subcontractors through the contract documents (Yoon et al., 2015). As specified by Bahamid and Doh (2017) and Jarkas and Haupt (2015), risk transfer is shift and changes, along with ownership, from one party to a third party without changing the total amount of risk or reducing how crucial the risk sources are. In addition, Jarkas and Haupt (2015) stated that shifting the financial risk via insurance, such as "all risks and labor compensation" coverage policies which are widely accepted contractual requirements and therefore it is practiced by contractors. Transfer of risks is also an important risk response method because it could prevent certain losses and to achieve the organizational objectives of each party. Contractors however are reluctant to forward claims for losses with the idea of not affecting better relationship with the Employer. In this instance, the method of insurance is significant (Barkley, 2017; Perera, et al., 2009).

2.10.2 Risks avoidance

Removing the occurrence of potential risk in a construction project as well as avoid projects called as risk avoidance (also called risk elimination) is a strategy to remove some potential risk by eliminating the risk (PMI, 1996; Yoon et al., 2015). In here, both refusals to accept the action taken or ensure that the risk is not going to continue and considered (Bahamid & Doh, 2017). As per Perera, et al. (2009), risk avoidance, which is considered the most effective risk handling method and can be achieved with the pre determination of events, mostly at the estimating stage and by keeping written records and giving written notices of possible negative events to the consultant. Consequently, Wang and Chou, (2003) explained either rejection or change is an alternative to remove some hidden risk.

2.10.3 Risks acceptance (Risks retention)

Once, risk occurred, if it is accepted, such strategy called as risk acceptance or risk retention. Such strategy can be either active or planned and passive or unplanned (Merna, Chu, & Al - Thani, 2010; Yoon et al., 2015). As specified by Bahamid, and Doh, (2017) risk retention occupy considering that a particular risk condition exists and making a mindful steps to accept the level of risk, without applying in any special efforts to control it.

2.10.4 Risks mitigation (Risks reduction)

The strategy uses to reduce the occurrence of risk called as risk reduction or risk mitigation (Yoon et al., 2015). At the same time, Szymanski (2017) expressed that it is limited the expose to it or simply by minimizing the probable damage. Also Jarkas and Haupt (2015) expressed risk mitigation is a procedure used to eradicate the negative consequences of risks through uninterrupted improvement of the policies, procedures, education and trainings. For instance, developing and implementing a safety practices and regular construction equipment maintenance plan can considerably reduce accidents on sites and obviate unnecessary delays and costly repairs for break-downs.

2.11 Risk response measures

Risk response is an action taken to avoid risks to reduce the occurring probability of risks, or to mitigate losses arising from risks via preparing response plans as well as select suitable measures to handle the risks (Wang & Chou, 2003). According to PMI (2008), it is required to select suitable measures for the above risk response strategies after identify, classify, analyse, assess and allocate the risk from the contracting parties. The Table 2.5 provides the details of risk response strategies as well as risk response measures which have been identified throughout the literature.

Table 2.5: Risk response strategies and measures identified by past researches

Risk Response Strategy	Risk Response Measures	Reference
Risk Transfer	Transferred risk via contract documents from main contractor to subcontractor	Perera, et al. (2009); Yoon et al. (2015)
	The contractors can transfer the financial losses occurred due to all risk events through insurance companies	
	Claiming cost of damages	Perera, et al., (2009)
	Employer can transfer obligations to contractor via selecting the path as design and built by contractor	
	Transfer the risk management responsibilities to third parties (consultant)	Ahmadi et al. (2015); Ashley et al. (2006); Wang and Chou (2003)
	Transfer the risks to other parties via contractual shifting (Performance encouragement, insurance, warranties, bonds, etc.)	Barkley (2017)
	Assign uncertain tasks under contractor's scope	Szymanski (2017)

Risk Response Strategy	Risk Response Measures	Reference
Risk Avoidance	Contractor can go for high bid price for tendering as well as specified required conditions in the bid	Wang and Chou (2003) Yoon et al. (2015);
	If the current construction activities are affected then contractor can go for an alternative construction method to keep the construction schedule alive	
	Countries are financially and politically unstable then avoid bidding for the above construction projects	
	To avoid unreasonable claims inspect the houses and buildings for cracks before commence the construction	Perera, et al. (2009)
	If the records are having doubts or issues continuously keep the crack inspection records	
	Changed the plans as well as designs to avoid risks	Ahmadi et al. (2015); Ashley et al. (2006); Wang and Chou (2003)
Risk Acceptance (Risk Retention)	Doing nothing and accepted any of result	Ahmadi et al. (2015); Ashley et al. (2006); Wang and Chou (2003)
	Develop an emergency plan in case any risk event has been occurred	Yoon et al. (2015)
	Accept lower profit for any affected event	
	Employment of specialist from outside in case in house skills not available	Perera, et al. (2009)
	Sub-Contracting of works/ Keep own machinery and plant for works	
	Minimize unnecessary delays in decision making	Naji, and Ali (2018)
	Accept all the results arising due to risks and keeping a contingency plan	Perera, Samarakkody, and Nandasena (2020)
Risk Mitigation (Risk Reduction)	Jointly work to obtain approvals for the works	Perera, et al. (2009)
	Cooperation with other contractual parties such as employer, contractor, sub-contractor, engineer (team work)	
	Carried out education and training secessions to the employees of the organization	Flanagan and Norman (1993); Yoon et al. (2015)
	Control risk magnitude by reducing any of risk components which severely affected the project	Ahmadi et al. (2015); Ashley et al. (2006); Wang and Chou (2003)

Considering all above, the Table 2.5 indicated the most suitable risk response measures identified by the researchers to minimize the risks in all construction projects in worldwide and those measures can be also usable to transfer, avoid, accept and reduce the risk while engage in highway construction projects in Sri Lanka with contractor's perspective.

2.12 Road construction projects

As specified by Laurance and Balmford (2013) and Laurance et al. (2014), it is very difficult to predict the rate of expanding the total length and spatial extent of roads in globally. Nearly 90% of new projects occurring as well as proposed infrastructure projects are going to be occurred in developed countries (Dulac, 2013). Kumar, Sheikh and Asadi (2017), Myers, Mittermeier, Mittermeier, Fonseca, and Kent (2000) and Sodhi, Koh, Brook, and Ng (2004) mentioned that road construction projects are having higher risk compared with other projects and due to above projects, tropical biodiversity would be affected seriously since the developing nations are considering the road development as a crucial economic drive. In developing countries for the acceleration of the growth of economy, the infrastructure projects such as roads provide greater impotency (Ghoddousi & Hosseini, 2012; Wang, Dulaimi, & Aguria, 2004).

As identified by Walimuni, et al. (2017), lots of environmental hazards directly occurred in Sri Lanka due to road construction activities. Considering above hazards, it has become a reason for the impacts on the physical and ecological environment mainly, in terms of land, water and air pollutions. According to research outcomes of Chaudhary (2011), comparing with other projects of development, the road development projects are involving wide variety of environmental impacts. Further, Ashworth (1996) and Karunasena, Abeydeera, Ranasinghe, and Pratheeban (2017) specified that construction projects are affected due to human activities as well as social challenges. Therefore, environment related statutes, regulations, codes and general policies have lot of interferences for the construction industry in terms of environmental protection (Ofori, 1992; Walimuni, et al. (2017).

As specified by Kumar, Sheikh, and Asadi (2017), Perera et al. (2014) and Zayed, Amer and Pan (2008), implementation of highway construction projects are highly involved with risks as well as uncertainties.

2.13 Highway construction projects in Sri Lanka

ADB (2011) remarked the objectives of national highway sector improvement are basically expanding the economic opportunities for leading to higher income.

Further, improvement of transport efficiency with improved road sector institution and policy and upgraded and maintained national highway network that reduced transport cost and travel time. Hence, Karunasena et al. (2017) convinced that highway construction is the better mode of transportation as a solution for high traffic flows. According to the RDA (2021), details of the completed highway (expressway) projects are mentioned in Table 2.6.

Table 2.6 - The completed highway projects in Sri Lanka

Code	Expressway	Length (km)	Total Cost Rs. (Billion)
E001	Southern expressway	200.451	293.26
E002	Outer circular way	28.867	56.6
E003	Colombo Katunayake	25.800	65.0
E006	Andarawewa Hambantota	16.558	46.3

According to the Table 2.6, nearly 272 km of total length was introduced as highway in road network of Sri Lanka. Apart from that, there are ongoing expressway projects in Sri Lanka. The road network of the highway projects are given in Figure 2.2.

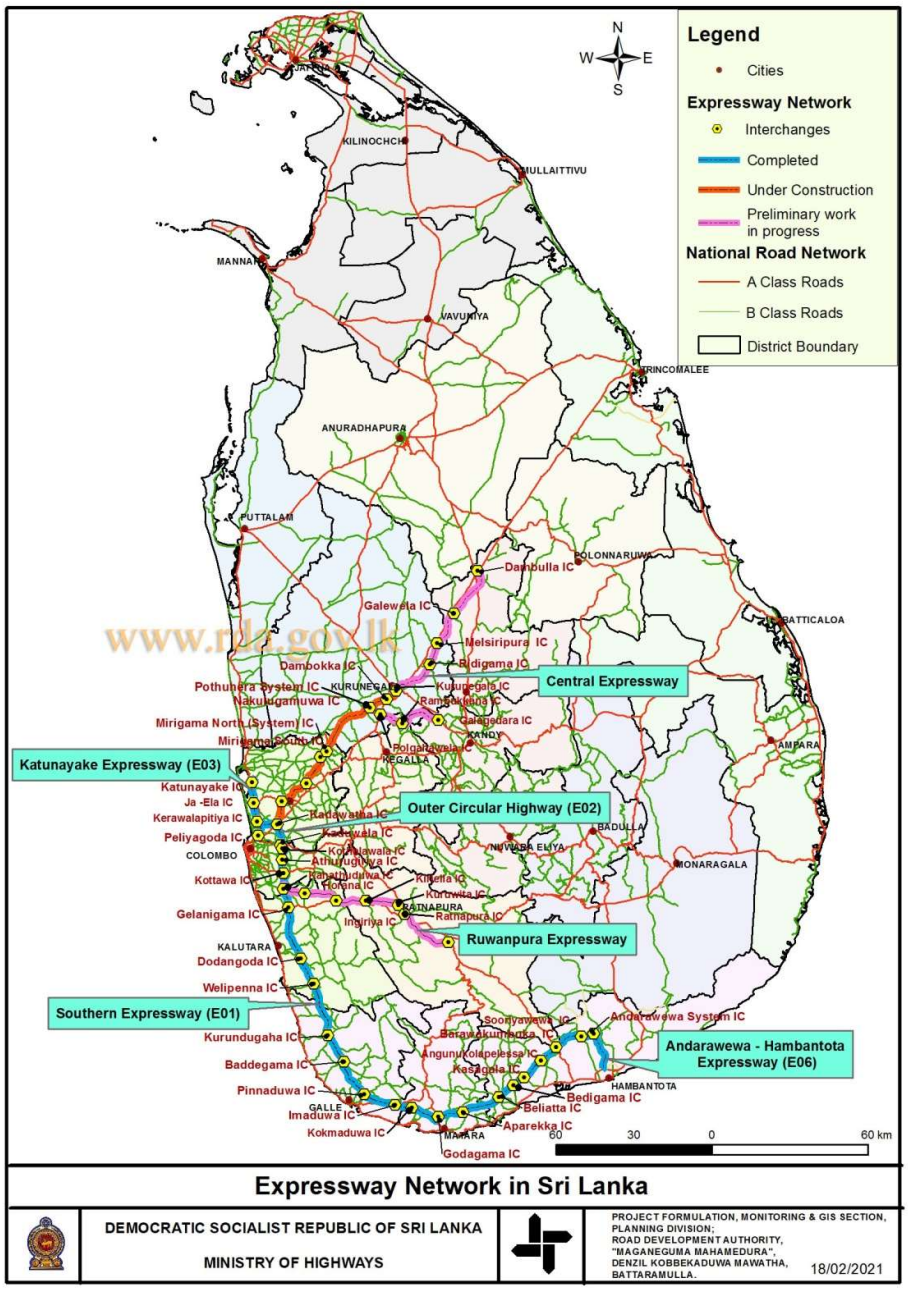

Figure 2.2: Highway network as at 18.02.2021 (Source RDA, 2021)

As per the Figure 2.2, mainly 6 highway construction projects were implemented and some of them are still at the construction phase. According to the Annual report 2019 of Ministry of Sri Lanka, 2 highway construction projects are currently in processing in Sri Lanka and above 2 projects are Central expressway and Ruwanpura expressway (Annual Report 2019 of Ministry of Finance, Sri Lanka).

Even though, highway construction projects are considered as a factor of booming the country's economy, various challenges are encountered as accidents, disputes, natural disasters and so on (Priyantha, Karunasena, & Rodrigo, 2011). Moreover, agreeing to so-called challenges Palliyaguru, Karunasena, and Ang (2018) mentioned that wide area of social, economic and environmental challenges have to be addressed. Thus, the risks in highway construction are discussed as specified below.

2.14 Risks in highway construction projects

Since highway construction projects are geographically spread in a wider range, most of the studies have confirmed that the risk involvement in those projects are higher than other projects (El-Sayegh & Mansour, 2015; Reilly & Brown, 2004). In reality construction of highway projects have more risks and uncertainties comparing to other construction projects. The major reasons for that are high investments as well as complexity and the dependency on challenges of social, economic as well as political (Ahamadi, Behzadian, Ardeshir, & Kapelan, 2017; Molenaar & Wilson, 2009).

Mainly, the risks in highway construction projects can be divided into two parts such as; internal and external. Further to be more convenient, the internal risks can be categorized as technical, site, and commercial risks. Then the external risks can be categorized as environmental, political, and socioeconomic risks (El-Sayegh & Mansour, 2015). Khodeir and Mohamed (2015) expressed according to his research experience that the external risks are highly impacted rather than the internal risks in construction projects. According to Dhanasinghe and Perera (2008), Sato, Kitazume, and Miyamoto (2005) and Kumar, Sheikh, and Asadi (2017), the road projects can be categorized as social capital development projects and risks can be experienced during the whole life cycle since the projects are covered wider geographical area, threats due to conditions of underground as well as long length and time duration of the project. Further, Alamgir et al. (2017) categorized that the risks occurred due to construction of highway projects such as;

- Environmental impacts and risks
- Challenges for building and maintaining

- Financial risks
- Socio political risks

Further to Badalpur and Nurbakhsh (2021) and Karunasena et al. (2017), it is identified that in highway construction projects, the environmental risks and social impacts are the highly categorized challenges. Considering all above, the environmental risk factors has a significant role as well as giving sever impact in the process of highway construction projects. Hence, author identified that it is better to address the environmental risks factors considering the highway construction projects. Further, as described above as well as under "Risk allocation to contracting parties", the contractor has suffered severely due to risks in highway construction projects. Accordingly, it is better to discuss how the risk allocated to contractor in highway construction projects.

2.15 Risk allocated to contractor in highway construction projects

Risk can be occurred in any construction projects. It is very difficult to find risk free projects. Since the construction environment is very competitive comparing with other contracting parties the contractor's situation is worse (Taofeeq, Adeleke, & Hassan, 2019). Omopariola, Windapo, and El-Gohary (2021) also agreed with above statement and specified that in construction industry contractors are facing various challenges and due concerning the environmental aspects the contractor has to arrange the environmental management plan. At the same time, contractor should be aware of the possible environment risks factors and concerns at the site. Similarly, Azis, Memon, Rahman, Latif, and Nagapan (2012) specified that to achieve the sustainable goals, contracting parties should align with sound environmental practices. Further, Jiao, Zhang, and He (2015) also indicated some environmental related issues in highway construction projects. However, Zhang, Yang, Wang, Yang, and Chen (2020) convinced that the significant impacts to the ecological environment occurs due to highway construction projects. Hence, the contractor's major responsibility would be to minimize the environmental risk factor in highway construction projects. The study done by Sharaf and Abdelwahab (2015) discovered that environmental risks in highway construction projects are in medium rating concerning the client, contractor and consultant perspective. According to Wang and

Chou (2003) confirmed that the risk is more controllable by the contractor and employer has the greater tendency to allocate the risk to the contractor. However, Badalpur and Nurbakhsh (2021) and Zou et al. (2007), specified that very limited studies have discussed risks from the perspective of contractors or sub-contractors in all phases of a construction project. Accordingly, the author has identified that, especially the contractor is the main character in construction industry that is severely affected with the construction risks. Therefore, this study becomes specific with fulfilling the above research gap.

2.16 Theoretical framework of the research

The theoretical framework is prepared to provide a better idea using geographical model with the help of the literature findings. The target is to identify the information available with the literature review and the output can be generated via collecting and analysing above data as well as how to fulfil the requirements of aim and objectives by finding the research gap.

Accordingly, by referring the literature, it has identified the risks in construction industry, what is risk management and what is risk management process in construction industry. As per Table 2.1, “Phases of risk management process” were identified and as per Table 2.2 (Risk classification), it is clearly identified that most of the construction projects were affected due to environmental risk. Further, the Table 2.3 elaborate the available environmental risk factors in construction industry. At the same time, with the support of the literature, it has categorised important risk response strategies and as per the risk allocation is clearly understood that the contractor as well as the client were severely suffered due to construction risks.

The theoretical framework for this research is illustrated in Figure 2.3 and for the success of the research four number of research gaps were identified in this model.

Theoretical framework for management of environmental risks in highway construction projects

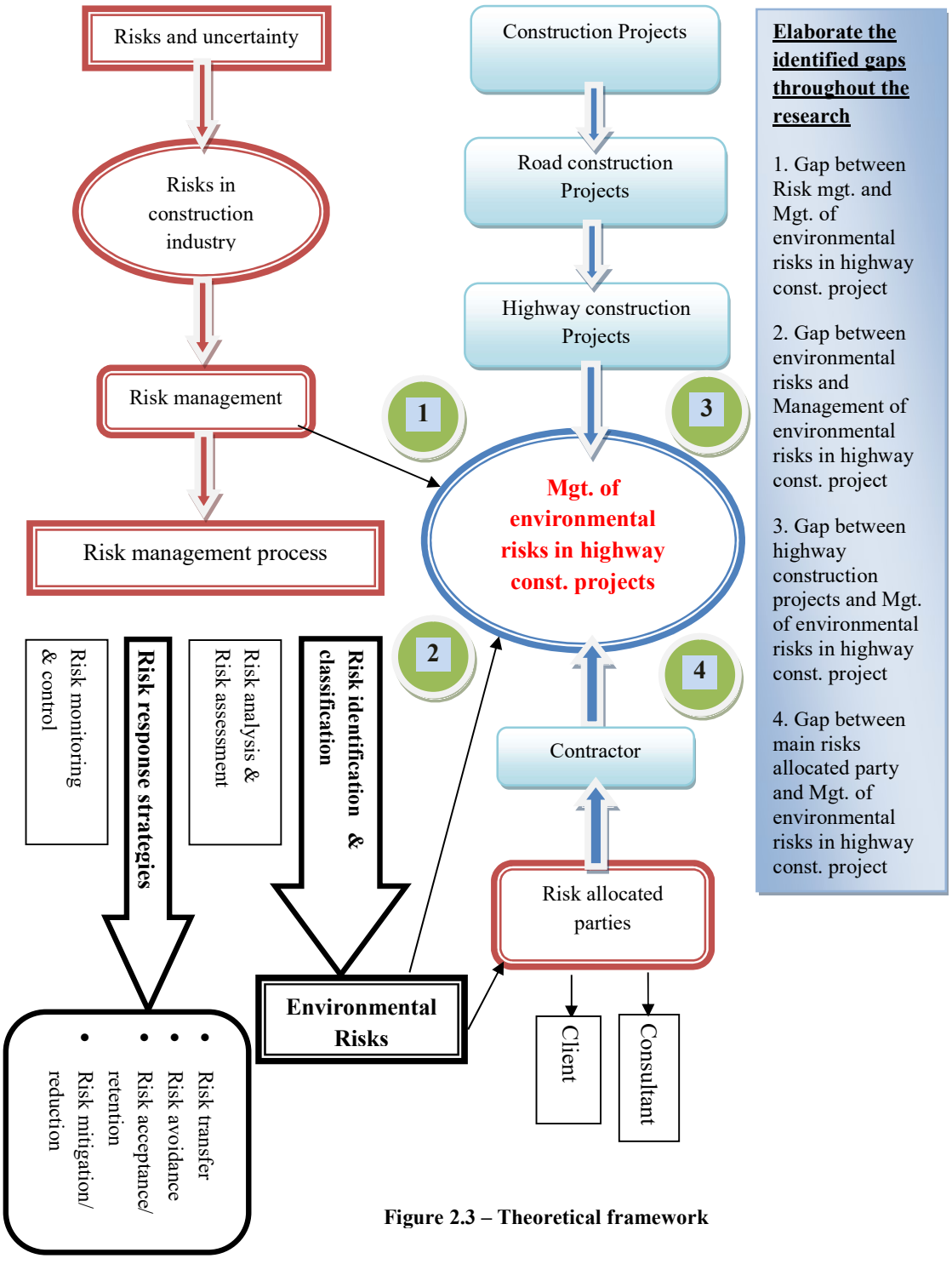

Figure 2.3 – Theoretical framework

2.17 Why is the management of environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective is important

Edward and Bowen (1998) and Perera et al. (2014) identified risk management as an important tool to cope with construction risks and to overcome above problems in a project. Referring to the literature, many research papers available in relation with risk management in construction industry (Al-Shibly et al., 2013; Bahamid & Doh, 2017; Dako, 2019; Jayasudha & Vidivelli, 2016). At the same time, several researchers discussed about the risk management in road and highway construction projects (El-Sayegh & Mansour, 2015; Perera et al., 2009; Perera et al., 2014; Walimuni, et al., 2017; Wang & Chou, 2003). Further, only limited number of research papers expressed about how to manage the environmental risk factors in road and highway construction projects (Alamgir et al., 2017; Coffin, 2007; Laurance et al., 2015; Mann et al., 2021; Trombulak, & Frissell, 2000). Further, as expressed in chapter 2.12 (Road construction projects), it is clearly understood that highway construction projects are fraught with higher levels of risks.

At the same time, there are only few research findings available in relation with management of environmental risk factors in highway construction in Sri Lankan contest.

Since the owner has a greater tendency to allocate the risk to the contractor (Wang & Chou, 2003), the contractor has a higher risk than the other contracting parties. RDA (2016) determined some key environmental aspects during the EIA process for instances, geo technical aspects, hydrological impacts, ecological impacts, water, air quality, noise and vibration. Therefore, through highway construction a wide variety of possible environmental risks would be proactively addressed. Besides, referring to the literature, only few research papers are available in relation with management of environmental risk factors in highway construction projects. To fulfil above research gap, the author decided to carry out a research to find how to manage the environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective.

2.18 Summary

To expand the economic opportunities and gain higher income, the improvement of national highway projects are very essential. This may also help to reduce traffic, transport cost as well as to minimize the travel time. Accordingly, the Sri Lankan government has already completed several highway construction projects and engage with several other highway projects to fulfil above requirements. Further, risks and uncertainties are common in any construction projects. But comparing to other construction projects, the highway construction projects have more risks. Therefore, the risk management is very essential to successfully complete the above projects. Considering all above the literature review has been carried out and a theoretical model was prepared to identify and manage the most critical risk factor when engage with highway construction projects in Sri Lanka with contractor's perspective.

3 RESEARCH METHODOLOGY CHAPTER 3

3.1 Introduction

The aim of this chapter is to find a suitable way of research methodology to achieve the desired targets. Further, it's provided a path to resolve the research problem as well as facilitate to answer the research question. The processes of the research methodology are research design, find available research approaches, select suitable research approaches for the study, find available data collection method, then select suitable data collection methods as well as data analysis techniques and finally provide conclusion and recommendation for the research.

3.2 Research design

The research design provides guideline to find the solutions to the research problem (Kumar, 2018) as well as provide conclusion to research problem (Tan, 2002). As per Akhtar (2016), it is the plan of the proposed research. Further research design is a systematic way to conduct the research via colleting, measuring and analysing the data (Kothari, 2004). According to Singh (2006), the strategy of the research design is to carry out a scientific and systematic process to find a suitable solution for a specific issue. Elmabruck and Almwber (2018) specified that the research design provided guide line to understand the required information as well as how to collect the required information via questionnaire as well as select best team to collect the information and what are the methods to be used to collect the information.

3.3 Research approaches

Mohanjan (2017) explained that research approach is the action plan for the research and confirmed that it helped to go for a systematic and effective research. Qualitative, quantitative and mix approaches are the main three types of research approaches to carry out a research (Creswell, 2009). Kothari (2004) expressed that from above three types; commonly used qualitative and quantitative approaches. According to Thurairajah, Haigh, and Amaratunga (2006), research approach is the procedure to organize research activities and integration of collected data to achieve the aim and objectives of the research.

3.3.1 Available research approaches

Qualitative approach

As expressed by Goundar (2012), qualitative research approach is non numeric as well as provides idea using words and involve with qualitative phenomena. At the same time, it allows to assess opinions, behaviors as well as to find new relationships to the researches (Saunden, Lewis, & Thornhill, 2009). In order to carryout qualitative research as per Yilmaz (2013), it is required to collect and analyze the data using document analysis, expert interviews and observations from participants.

Quantitative approach

Quantitative research approach consists with numerical data and it generalizes the findings with maximizing the objectivity (Creswell, 2009). Further to Goertzen (2017), quantitative research dealing with numbers. As per Williams (2007), it's providing statistical approach to the research design. Goundar (2012) expressed that base of this method is to provide quantity or quantity measurement and required information via one or more quantities. At the same time to get the required output in satisfactory level, the researcher can evaluate the data with higher population (Rahman & Joadder, 2017).

Mixed approach

Mixed research approach is the combination of qualitative and quantitative methods (Harwell, 2011). According to Creswell (2013) and Creswell (2014), it comprises with data collection techniques of quantitative and qualitative methods and consists with analytical procedure. Further to above using mixed method, the researchers can analyze and evaluate the research problem very deeply and thoroughly rather than using single methods separately.

As specified by Williams (2007), the above three methods are the common approaches to conduct a research. According to the requirement the researcher can decide what will be the most appropriate research approach to be carried out the research.

3.3.2 Selected research approach for the study

The qualitative method was used to justify the environmental risk factors identified via literature review to highway construction projects as well as to Sri Lankan contest at the beginning of the study. Accordingly to validate, the above risk factors used semi structured interview with the support of 10 expertise who are having more than 10 years' experience in construction industry and more than 5 years' working experience in highway construction projects in Sri Lanka. Further to discussion had with interviewers, same as well as modified and newly identified environmental risk factors used to evaluate them under quantitative method for the success of the research and used questionnaire survey to find the significance of the selected environmental risk factors. At the end of the research to proceed with final outcome, used mix method to develop a framework to manage the environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective. At the same time, Carbone and Tippett (2004), Hoseini, Hertogh and Bosch-Rekveldt (2021) and Hwang, Shan, and Supa'at (2017) were successfully carried out their risk management studies in relation with mixed approach.

3.4 Selected methods for data collection

Kothari (2004) specified that research method mean suitable instrument to carry out the research in proper manner. According to Taylor and Goshal (2006), most frequently used data collection methods are document review and analysis, observations, interviews and questionnaires. Accordingly for this research, collection of literature review, interviews as well as questionnaire surveys were mainly used to justify the identified environmental risk factors in highway construction projects in Sri Lanka in relation with contractor perspective.

3.4.1 Semi structured interview

According to Burnard, Gill, Stewart, Treasure, and Chadwick (2008), using this method, the researcher can get the experts experience as well as beliefs and opinions in the relevant field. At the same time, this method is one of the best method to collect the information since the researcher can directly deal with respondent (Punch, 2013). Further, interviews can be conducted via not only physically, but also via online. As specified by Sweet (2002), the quality of response and the

cooperation are very high in physical interviews while the refusal rate is very law. Further to Sweet (2002), the online interviews are carried out, since the physical interviews are not possible and interviewers have major role in controlling as well as supervision while proceeding with the interview. The researchers can handle the interviews in three different ways such as: structured, semi structured and unstructured. From above, the most convenient method is semi structured interview (Walliman, 2011). Considering above factors, this research was carried out using semi structured interview (Annexure A).

3.4.2 Questionnaire survey

As expressed by the Chio, Choi, and Cho (2004) researchers can collect larger number of information with the help of larger population via questionnaire survey and it's the advantage of this procedure. At the same time, the main disadvantages of this method are due to busy schedule, the respondents do not provide sufficient answers and provide incomplete feedbacks as well as due to improper understanding about the requirement respondents were provide wrong feedbacks. Further to Kumar (2018), this is widely use method to gather the information and the researcher has to prepare the questionnaire in easy way to understand and answer by the respondent. The aim of the questionnaire survey is to rank the collected data via literature as well as interviews. Using this method, the researcher can validate above data in a consistent manner (Taherdoost, 2016). Considering above factors, this study used the questionnaire surveys (Annexure B and C).

3.5 Data analysis techniques

After collecting the data from literature as well as semi structured interviews, validated them and forwarded to experts in highway construction projects to get their input via questionnaire surveys. Further, severity index, cronbach alpha calculation, mean weighted rate and average method used to analyse the data and rank the output.

3.5.1 Manual content analysis

Manual content analysis is used to analyze the data which were collected via the preliminary interview at the beginning of the study. At the same time using the

technique of content analysis, the researcher can get clear idea via interpreting and coding the texts or documents (Lewis, Zamith, & Hermida, 2013). Accordingly using this method, the researchers can convert the qualitative data in to quantitative data.

3.5.2 Severity index (Analyze the risk factors)

Once collected data from the questionnaire survey, the severity index was calculated to analyze the significance of each risk factor and rank them in order. Previously this method has been carried out by several researches to analyze the severity index of risk factors (Fang, Fong, & Shen, 2004; Sun, Fang, Wang, Dai, & Lv, 2008). Hence to find the criticality of each risk factor, the severity index analysis used in this research.

$$\boldsymbol{S_j^i = \propto_j^i \beta_j^i} \qquad \text{(Equation 1)}$$

$$\boldsymbol{RS^i = \frac{\sum_{j=1}^{n} S_j^i}{n}} \qquad \text{(Equation 2)}$$

In above equations,

'n – Number of response

S_j^i – Evaluation of risk severity of ith risk factor by the jth respondent

$\propto_j^i$ – Evaluation of frequency level of risk occurrence by the jth respondent

β_j^i – Evaluation of the significance of risk occurrence by the jth respondent

RS^i– Risk Severity Index for the ith risk factor.

3.5.3 Cronbach's alpha calculation (Internal consistency of sample)

In 1951, the above calculation was developed by Lee Cronbach. It's provides the measurement of internal consistency of any test or scale. The consistency describe the interrelation ship of each items in the test and the test results lying between 0 to 1 (Tavakol & Dennick, 2011). As prescribed by Gain, Mishra, and Aithal (2022) and Iramanerat, Yudkowsky Myford, and Downing (2008), Cronbach alpha used to test reliability of response and before use the data for a test or research, it is required to determine the internal consistency for the assurance of effectiveness. Addition to that, reliability estimate provides an idea of measurement error with related test. The formula is as follows (Amirrudin, Nasution, & Supahar, 2021).

$$\propto = \frac{k}{k-1}\left(1 - \frac{\in Vi}{Vt}\right) \qquad \text{(Equation 3)}$$

Where,

K = Number of Factors

Vi = Sum of the Risk Factors Variances

Vt = Variance of Total Scores in Severity Index

When used the above formula, Table 3.1 shows the thumb rule of Cronbach alpha and accordingly the researchers can find the accuracy and the internal consistency of a data set (Stephanic, 2014). Considering all above, this method used to find the accuracy and internal consistency of the risk factors.

Table - 3.1 Thumb rule of Cronbach alpha for the levels of consistency (Stephanic, 2014)

Coefficient of Cronbach's alpha	Reliability level (Internal consistency)
$\propto$ equal or More than 0.90	Excellent
$\propto$ *between* 0.90 and 0.80	Good
$\propto$ *between* 0.80 and 0.70	Acceptable
$\propto$ *between* 0.70 and 0.60	Questionable
$\propto$ *between* 0.60 and 0.50	Poor
$\propto$ Less than 0.50	Unacceptable

3.5.4 Mean weighted rate (MWR) system for questionnaire survey

This method used to find out most suitable factor among set of factors (Gosavi, 2015). The formula is given below.

$$\mathbf{MWR} = \sum_{i=0}^{5} Xi * Fi/N \qquad \text{(Equation 4)}$$

F_i - frequency of responses (range from 1 to 5); Xi - responses to specific rating point; N - number of responses

To find the relative importance of a factor, it can use mean weighted rate (Everitt & Skrondal, 2010) as well as Madushika, Perera, Ekanayake, and Shen (2020) confirmed the validity of the above equation. Hence, after conducted the second questionnaire survey, this method used to determine the most suitable risk response measures.

3.5.5 Average (Analyze the risk allocation to contractor)

For the assessment of risk allocation of significant risk factors to contractor, it is required to analyses the second stage questionnaire survey results and get the average percentage of risk allocation

$$A^i = \frac{\sum_{j=1}^{n} P_j^i}{n} \qquad \text{(Equation 5)}$$

Where;

A^i – *Average Percentage of Risk allocation of i^{th} party*

P – *Rating (percentage) of each Factor given by j^{th} respondent*

n – *Number of responses*

3.6 Research process

This process highlights the required actions to be carried out the research in a convenient manner. Accordingly, each and every step should be properly arranged and it will help to minimize the errors as well as the researcher will be able to fulfil the desired targets. Figure 3.1 highlighted the process of this research.

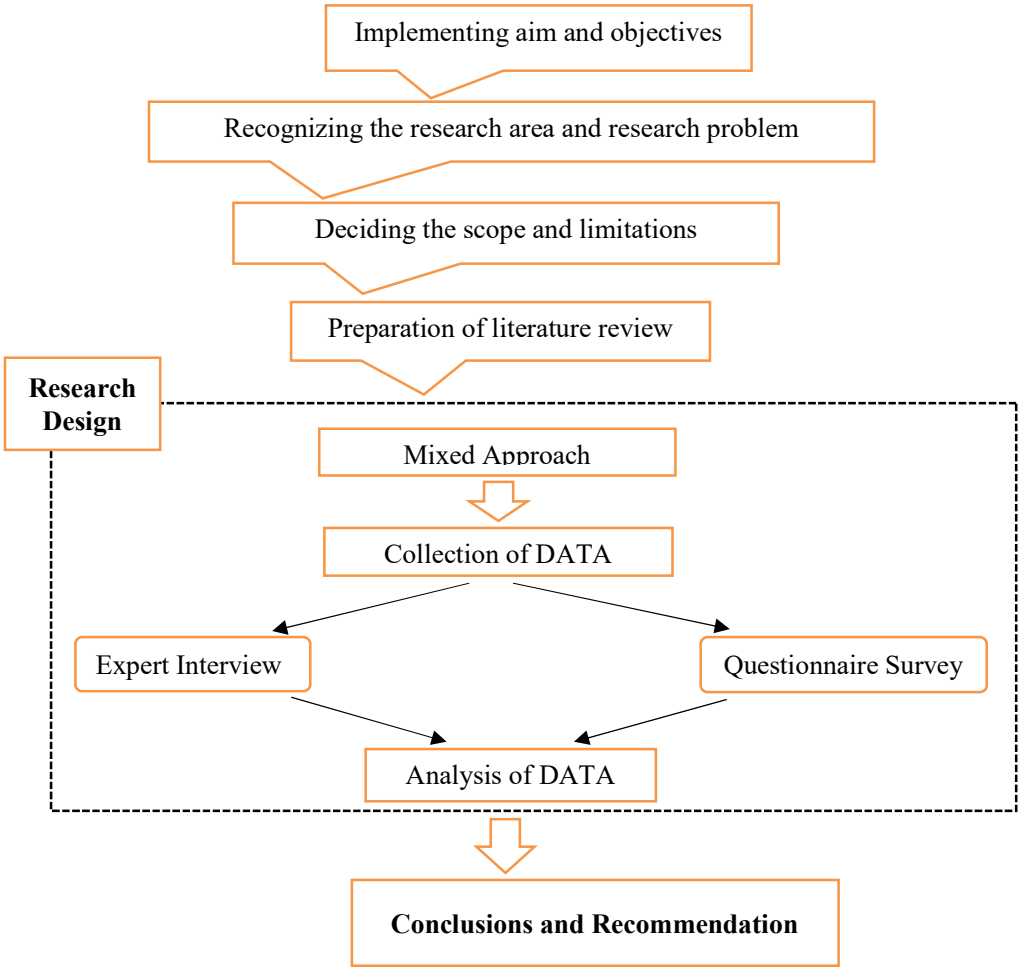

Figure 3.1 Research process

Figure 3.1 provided each and every steps of the research process. All data collection methods, approaches as well as data analysis techniques were illustrated in the figure. The required basis information was gathered via literature review and validates the above data via interviews with the help of the expertise. Further, the researcher can used above gathered information as the foundation for the questionnaire survey and conclusion and recommendation can be given after analysed the questionnaire survey details.

3.7 Summary

This chapter describe how the writer focused to fulfil the desired aim and objectives of the research. This chapter covered with the available as well as selected research approaches, data collection methods, data analysis methods and how it designed. Accordingly, the mix approach has been selected to carry out the research and collection of literature review, semi structured interview and questionnaires survey used as data collection methods. Further, manual content analysis and severity index used as data analysis method to achieve the desired targets.

4 ANALYSIS AND RESEARCH FINDINGS CHAPTER 4

4.1 Introduction

This chapter focuses on analysis the research findings gathered via expert interviews as well as structured questionnaire survey which carried out in two stages and discuss the objectives. At the same time, the final outcome of this chapter is to develop a framework to manage environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective.

4.2 Semi structured interviews with experts

The above interviews were carried out with experts who work with contractor's organization having more than 10 years' experience in construction industry as well as having more than 5 years' experience in highway construction industry. At the same time, above expertise were interviewed with the help of the interview guide line attached in Appendix A and approximately it was consumed 60 to 75 minutes for the above interview. Further, due to Pandemic situation all the interviews were proceed via online.

4.2.1 Objectives of semi structured interviews

Identify environmental risk factors in relation with highway construction projects in Sri Lanka, is the main objective of those interviews. Further, the gaps which were identified in literature review were filled via above expert interviews. At the same time all the environmental risk response strategies / response measures and most risk allocated parties which identified in the general construction industry as well as highway construction projects were listed out and validated with respect to highway construction projects in Sri Lanka via expert interviews.

4.2.2 Expert's profile of semi structured interviewees

For the semi structured interview, ten number of expertise have incorporated their valuable ideas who are working with contractor's organizations in Sri Lanka having experience in construction industry and highway construction projects. The details of participants specified in Table 4.1.

Table 4.1: Profile of expert interviewees

Code of Interviewee	Designation	Experience in construction industry (Years)	Experience in highway cons. projects (Years)
EI - 1	Environmental Specialist	20	05
EI - 2	Construction Manager	13	10
EI - 3	Senior Quantity Surveyor	17	05
EI - 4	Senior Quantity Surveyor	15	06
EI - 5	Environmental Engineer	20	10
EI - 6	Hydrologist (Environmental Management)	14	14
EI - 7	Senior Engineer	16	10
EI - 8	Environmental and Social Safe Guard Officer	15	10
EI - 9	Project Quantity Surveyor	11	05
EI - 10	Claims Engineer	40	14

As specified above, ten number of interviewers selected for the sampling by satisfying two criteria for the purposive sampling requirements who are having more than 10 years of experience in construction industry and more than 5 years of experience in highway construction projects to share their experience for the research. Further, the interviews were allowed to propose new environmental risk factors as well as risk response strategies/ measures according to their experience and knowledge.

4.2.3 Analysis of findings of expert's interviews

With the help of manual content analysis, the risk factors which collected via literature review were analysed as per the discussion had with the expertise. If the factors are directly applicable to highway construction projects in Sri Lanka with contractor's perspective, then used them as it is for the questionnaire survey round 1. Further some risk factors were modified according to Sri Lankan contest and then used for the questionnaire survey. When the risk factors are having same meaning, then amalgamated to one specific risk factor and proceeded with questionnaire survey. Further some other new risk factors were considered for questionnaire survey which were identified as specifically valid for highway construction projects in Sri Lanka. The details of findings as specified below.

4.2.4 Findings of semi structured interview

Through the literature review, many environmental risk factors were identified which were common to the construction industry. Since all of above risk factors were not related to highway construction projects as well as Sri Lankan contest using interviewee's feedback, modified some of selected risk factors as well as found some new environmental risk factors by fulfilling research requirements and used in questionnaire round 1. At the same time, the other set of risk response measures as well as environmental risk allocated parties which identified via interviewee's feedback were used in questionnaire survey 2.

4.2.4 (a) Risk factors in highway construction projects

Using the literature review, 41 number of environmental risk factors were collected in generally. After the discussion had with the expertise, 09 risk factors validate that they can use as it is as environmental risk factors and 08 number of risk factors were modified according to applicability of Sri Lankan contest and presented in *italic letters*. At the same four 04 number of risk factors amalgamated 02 modified risk factors which highlighted in ***italic bold letters*** and 17 risk factors separately covered with five 05 risk factors and indicated the **risk factor numbers in bold letters**. Further, three 03 risk factors were removed from the list since they were not applicable. At the same time, 13 number of risk factors identified newly were showed in **bold letters**. Accordingly, altogether 37 environmental risk factors were identified after expert interview.

Table 4.2: Findings of semi structured interview (Environmental risk factors in highway construction projects after interview)

Environmental risk factors in general before Expert Interview		Environmental risk factors in highway construction after Expert Interview
Risk factors identified in literature and selected as it is as environmental risk factors		
Adverse weather conditions	1	Adverse weather conditions
Introduction of chemical pollution	2	Introduction of chemical pollution
Exotic species invasions	3	Exotic species invasions
Human invasions	4	Human invasions
Modification of animal behavior	5	Modification of animal behavior
Impact on local communities	6	Impact on local communities
Perceived Environmental Impact of Project	7	Perceived Environmental Impact of Project
Landscape change and fragmentation	8	Landscape change and fragmentation

Environmental risk factors in general before Expert Interview		**Environmental risk factors in highway construction after Expert Interview**
Landslides in mountainous areas	9	Landslides in mountainous areas
Risk factors identified via literature review and modified as environmental risk factors		
Noise and other atmospheric effects	10	*Noise and vibration*
Use of raw materials and natural resources	11	*Natural resources depletion in Sri Lanka like soil, sand, aggregate etc.*
Ecologically sustainable development (ESD)	12	*Not according to Ecologically sustainable development (ESD)*
Difficulty to access the site (very far)	13	*Difficulty to access the site due to most sensitive areas*
Compliance with law and regulation for environment issue	14	*Non - Compliance with law and regulation for environment issue*
Site conditions	15	*Poor site conditions which not complied with EMP*
Road as habitat corridor and conduit	16	*Road as habitat corridor*
Interference with natural drainage patterns	17	*Impacts on the natural drainage patterns and issues of irrigation water*
Risk factors identified in literature and modified and amalgamated as environmental risk factors		
Floods, earthquakes, etc.	18	***Floods***
Emergencies		
Waste management and disposal	19	***Improper construction and solid waste disposal***
Solid and Liquid waste		
Several risk factors identified in literature and amalgamated to one risk factor as environmental risk factor		
Air and water Pollution	**20**	Air and water Pollution
Release to air		
Release to water		
Dust		
Mortality and Barriers to wildlife movement	**21**	Mortality and Barriers to wildlife movement
Road related mortality		
Barrier effect		
Road edges and road effect zone		
Physical and biotic edge effects		
Disruption of physical environment	**22**	Disruption of physical environment
Changes to hydrology and water quality		
Erosion and sediment transport		
Ecological damage	**23**	Ecological damage
Ecological conservation		
Contamination of land	**24**	Contamination of land
Ground conditions and contaminant		
Land Pollution		
Risk factors identified in literature and validated as not applicable		
Heritage conservation		Not applicable (80% said “No”)
Ecological road network theory		Not applicable (90% said “No”)
Ground movements		Not applicable (100% said “No”)
Newly identified environmental risk factors by the interviewees		
	25	**Loss of endangered and endemic**

Environmental risk factors in general before Expert Interview		Environmental risk factors in highway construction after Expert Interview
		flora and fauna species found in project areas
	26	**Public complaints and obstruction to the work from nearby residents**
	27	**Crop damage due to erosion**
	28	**Ground water depletion due to large excavation, cuts and tunnels**
	29	**Light and sound pollution where the road cross in sanctuaries**
	30	**Shade effect due to via duct or large bridges**
	31	**Loss of vegetation**
	32	**Loss of breading site**
	33	**Changes in cropping pattern and yield loss**
	34	**Loss of bio diversity**
	35	**Degradation of land due to material extraction**
	36	**Disturbances and fragmentation of natural habitats**
	37	**Disturbances for migration routes of animals**

According to the discussion, most of the interviewees specified and confirmed that (more than 80%) heritage conservation, ecological road network theory and ground movements were not experienced and not qualified as environments risk factors for the current research. At the same time, while some experts validate adverse weather condition as acceptable risk factor and some specified that due to highway projects adverse weather cannot occurred. As specified in literature "floods, earthquakes" described as general risk factor but according to expert interviews most confirmed that according to Sri Lankan contest occurrence of earthquakes negligible and hence floods can be selected as environmental risk factor. At the same time emergencies can occur at any time such as flood and according to experts' elaboration, it was modified and amalgamated under *flood*. Further as explained by interviewee No. 2, 5, 6 and 8 Risk factors "Release to air, "Release to water" and "Dust" amalgamated with "*Air and water pollution*". As elaborated by interviewee No. 5, 6 and 8 "Road related mortality", "Barrier effect", "Road edges and road effect zone", "Physical and biotic edge effects" amalgamated under "*Mortality and Barriers to wildlife movement*". According to Interviewee No. 5, 9 and 10, the risk factors "Changes to hydrology and water quality" and "Erosion and sediment transport" amalgamated to "*Disruption of physical environment*". While "Ecological conservation" amalgamated with "*Ecological damage*" as elaborated by interviewee No. 2, 5, 6

and 7, the “Ground conditions and contaminant” and “Land pollution” amalgamated with “*Contamination of land*” as explained by interviewee No. 6, 8 and 9.

Further to discussion had with interviewees directly identified 13 new environmental risk factors and shown in Table 4.2 under serial no 25 to serial no 37 and those are most suited for Sri Lankan contest as well as common for environmental risk factors in highway construction projects. Accordingly, Interviewee No. 5 expressed that “*loss of endangered and endemic flora and fauna species found in project area*, *light and sound pollution where the road cross in sanctuaries and loss of vegetation*” as new risk factors identified for this research. Further, Interviewee No. 2 introduce new risk factor as “*public complaint and obstruction to work from nearby residents*”. Meanwhile, Interviewee No. 6 elaborated three new risk factors such as “*crop damage due to erosion*, *ground water depletion due to large cuts and tunnels* and *loss of breading site*”. At the same time, Interviewee No. 7 expressed that “*shade effect due to via duct or large bridges*” as another new risk factor while Interviewee No. 8 explained that “*changes in cropping pattern and yield loss*, *loss of bio diversity* and *degradation of land due to material extraction”* as new risk factors according to their experience. The last set of new risk factors introduced by Interviewee No. 1 as “*disturbances and fragmentation of natural habitats* and *disturbances for migration routes of animals*”.

4.2.4. (b) Risk response strategies and related response measures in highway construction projects

Referring to literature review, 24 risk response measures were identified and referring to response from the interviewers (more than 80%), 7 risk measures were not considered since they were not related to environmental risk measures in highway construction projects. At the same time, 3 response covered under other risk measures. Further 1 risk measure considered as it is and 13 risk measures were modified (in italic) with interviewer’s experience in highway construction as well as 20 new risk measures (in bold) were introduced according to the experience and knowledge of the interviewers. Accordingly, 34 risk response measures were identified which coming under 4 risk response strategies; risk avoidance (RAV), risk

mitigate (RMI), risk transfer (RTR) and risk acceptance (RAC) for the 2 round of the questionnaire survey. Table 4.3 represent the details of risk response measures.

Table 4.3: Comparison of risk response strategies and related measures before and after expert interview

Environmental risk response strategies and related measures before expert interview	Se No	Environmental risk response strategies and related measures after expert interview
Transferred risk via contract documents from main contractor to subcontractor	**RTR 1**	*Transfer the risks at blasting, tunnel excavation including environmental rehabilitation via contract documents*
The contractors can transfer the financial losses occurred due to all risk events through insurance companies	**RTR 2**	*Contractor can transfer the losses caused by environmental risk occurrences through insurances companies*
Claiming cost of damages		Not related to environmental risk measures (100% said "No")
Employer can transfer obligations to contractor via selecting the path as design and built by contractor	**RTR 3**	*Transfer obligations to contractor via selecting the path as design and built by contractor*
Transfer the risk management responsibilities to third parties (consultant)		Covered under below risk measure. (RTR 4)
Transfer the risks to other parties via contractual shifting (Performance encouragement, insurance, warranties, bonds, etc.)	**RTR 4**	*Transfer the risk to other parties via contractual shifting other than insurances warranties and bonds*
Assign uncertain tasks under contractor's scope	**RTR 5**	*Assign all the environmental obligations under contractor's scope*
	RTR 6	**Damages to the cultivated areas to be claimed by client**
Contractor can go for high bid price for tendering as well as specified required conditions in the bid		Not related to environmental risk measures (100% said "No")
If the current construction activities are affected then contractor can go for an alternative construction method to keep the construction schedule alive	**RAV 1**	*If the current construction activities are affected by unexpected conditions, then go for alternative construction methods*
Countries are financially and politically unstable then avoid bidding for the above construction projects		Not related to environmental risk measures (90% said "No")
To avoid unreasonable claims inspect the houses and buildings for cracks before commence the construction	**RAV 2**	*Done the pre crack survey before the commencement of construction works.*
If the records are having doubts or issues continuously keep the crack inspection records	**RAV 3**	*Update the crack survey and maintain the records*
Changed the plans as well as designs to avoid risks	**RAV 4**	*Change the designs with the help of Environmental specialist for avoiding environmental risks*

Environmental risk response strategies and related measures before expert interview	Se No	Environmental risk response strategies and related measures after expert interview
	RAV 5	**Request the environmental clearance certifications from the employer before mobilizing to the site**
	RAV 6	**Maintain the continuity of irrigation and drainage canals/ paths within construction sites**
	RAV 7	**Dump disposals in an approved locations to avoid contact with terrestrial and aquatic habitats**
	RAV 8	**Erect sign boards at the places where animals are likely to be entered**
	RAV 9	**Make EIA report approval process very strict by government authorities**
Doing nothing and accepted any of result		Not related to environmental risk measures (100% said "No")
Develop an emergency plan in case any risk event has been occurred	**RAC 1**	*Develop an emergency plan and risk assessment matrix to identify severity and likelihood for expected risk factors*
Accept lower profit for any affected event		Not related to environmental risk measures (80% said "No")
Employment of specialist from outside in case in house skills not available	**RAC 2**	*Employment of external specialist in case in house skills not available*
Sub-Contracting of works/ Keep own machinery and plant for works		Not related to environmental risk measures (90% said "No")
Minimize unnecessary delays in decision making	**RAC 3**	Minimize unnecessary delays in decision making
Accept all the results arising due to risks and keeping a contingency plan		Covered under above risk measures (RAC 1)
	RAC 4	**Perform earthworks at nearby water bodies in dry periods**
	RAC 5	**Keep opening sizes of the bridges and culverts in large to free pass the flood flow**
	RAC 6	**Introduce crop diversification plan or provide temporary jobs for the victim farmers**
	RAC 7	**Introducing new forest reservations to compensate the damages to the environment**
Jointly work to obtain approvals for the works		Covered under below risk measure (RMI 1)
Cooperation with other contractual parties such as employer, contractor, sub-contractor, engineer (team work)	**RMI 1**	*All construction parties can jointly work as a team*
Carried out education and training secessions to the employees of the organization	**RMI 2**	*Demonstrate about the worker behavior pattern at construction at environmental conserved areas*
Control risk magnitude by reducing any of risk components which severely affected the project		Not directly related to environmental risk measures

Environmental risk response strategies and related measures before expert interview	Se No	Environmental risk response strategies and related measures after expert interview
	RMI 3	Involve with joint inspections, monitoring mechanisms with government regulatory bodies such as RDA, GSMB, NBRO
	RMI 4	Mitigate improper drainage and water logging by introducing new designs such as collector drains
	RMI 5	Control the velocity of the flood flow with suitable barriers
	RMI 6	Provide bio links, animal overpass, canopy bridges, eco duct and under passes designs
	RMI 7	Strictly adhere to environmental management plan
	RMI 8	Well maintain the natural drainage network in order to movement of the aquatic species
	RMI 9	Erect meshed fences to avoid entrance of animals to highways
	RMI 10	Educate project stake holders with reduce, reuse and recycle circular built environment principles in highway constructions
	RMI 11	Introduce a point system to encourage the use of recycle material
	RMI 12	Design the highways by considering environmental effects more than the cost effectiveness
RAV – Risk avoidance, RMI – Risk mitigation, RTR – Risk transfer, RAC – Risk acceptance		

As confirmed by all interviewees, mostly employers are trying to transfer obligations to contractor via "selecting the path as design and built by contractor". Further to that proposed to "assign all the environmental obligations under contractor's scope". Accordingly, expert interviewers explained that employer's aim is to transfer the obligations to contractors via contract document or any other method. Accordingly contractor has major responsibility in handling risks especially in highway construction projects.

When discuss about the environmental risk strategies interviewees 6, 7 and 10 proposed that when constructing highway projects it is required to concern about, environmental clearance certifications, EIA report approval process as well as EMP. Further, as explained by interviewee 2 and 6, they proposed damages to cultivated areas to be claimed by clients as well as introduce crop diversification plan or provide temporary jobs to victims. Meanwhile interviewees 1, 4 and 6 proposed to

erect sign boards at the places where animals likely to be entered, erect meshed fences to avoid entrance of animals to highways, provide bio links, animal overpass, canopy bridges, eco duct and under passes as well as well maintain the natural drainage network in order to movement of the aquatic species and accordingly those will help to minimize disturbances, mortality and barrier effect for the animals. Moreover, Educate project stake holders with reduce, reuse and recycle material and introduce point system to encourage them to use recycle material are the two new strategies introduced by interviewee 1 and 5. Further, as confirmed by all interviewees, change the design with help of environmental specialist for avoiding environmental risks as well as proposed by interviewee 7, design the highways by considering environmental effects more than the cost effectiveness are also important strategies identified throughout this interviews.

4.2.4. (c) Environmental risk factors allocated parties in highway construction projects

Identified 9 number of risk allocated parties via literature review and as per Table 2.4 (Risk allocation to the contracting parties), most of the authors indicated that main risk allocated parties as client, contractor and consultant. Further to response from the interviewers most of the experts emphasized that client (100%), contractor (100%) and the consultant (80%) are the most risk allocated parties in highway construction projects as represent in Table 4.4.

Table 4.4: Most risk allocated parties

Se No	Risk Allocated Parties	Experts Response	Remarks
1	Client	Major risk allocated parties	Interviewees identified that those parties has major risk allocation. Hence considered in questionnaire round 2
2	Contractor		
3	Consultant		
4	Supplier	Negligible	Interviewees identified that those parties has less risk allocation. Hence not considered for the questionnaire round 2
5	Sub-Contractor	Less	
6	Contracts	Less	
7	Designer	Less	
8	Govt. Agencies	Less	
9	External	Less	

Accordingly, client, contractor and consultant were considered as major risk allocated parties for the questionnaire round 2.

4.3 Questionnaire survey round 1

Findings of interviews were used to prepare the questionnaire. The professionals who are having experience in construction industry as well as highway projects in Sri Lanka, given their valuable support to conduct this survey. As shown in the Appendix B, the data has been collected via the questionnaire.

4.3.1 The objectives of questionnaire survey round 1

Determine the most significant environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective is the objective of this questionnaire survey. To achieve above target, it is required to find severity index of each risk factor and rank the above environmental risk factors. For the ranking purpose two main aspects were found via questionnaire survey such as; frequency level of risk occurrence and impact (significance) of environmental risk factors.

4.3.2 Respondents in questionnaire survey round 1

For the questionnaire round 1, there were 60 questionnaires distributed through the professionals who are having more than 5 years' experience in construction industry as well as more than 1 year experience in highway construction projects. Further 34 professionals were responded for the questionnaire survey and the contribution is 57%.

Among the respondents, 5 type of professionals participated to share their experience and those were environmental engineers, environmental officers, engineers, quantity surveyors and technical officers as summarized in Table 4.5.

Table 4.5: Profession and working experience of the respondents in questionnaire round 1

Profession	Working experience in construction industry (in years)					Working experience in highway construction projects (in years)				
	5-10	10-15	15-20	20-25	More than 25	1-5	5-10	10 - 15	15-20	**Total**
Environmental Engineer		3	2		1		3	2	1	**6**
Environmental Officer		3					1	2		**3**
Engineer	3	3	7		5	1	4	9	4	**18**
Quantity Surveyor	1	1	2			1	2	1		**4**

Profession	Working experience in construction industry (in years)					Working experience in highway construction projects (in years)				
	5-10	10-15	15-20	20-25	More than 25	1-5	5-10	10 - 15	15-20	**Total**
Technical Officer		1	2					1	2	**3**
TOTAL	**4**	**11**	**13**	**0**	**6**	**2**	**10**	**15**	**7**	**34**

As specified in above table, 6 environmental engineers, 3 environmental officers, 18 engineers, 4 quantity surveyors and 3 technical officers participated and 2 persons having 1-5 minimum experience and rest of 32 having more than minimum experience in highway construction projects in Sri Lankan contest.

4.4 Findings and analysis of questionnaire round 1

The main purpose of the questionnaire round 1 was to identify the most significant environmental risk factors in highway construction projects with contractor's perspective. As discussed in chapter 3, the significant was calculated using severity index method. Further to assumptions made by El-Sayegh, Manjikian, Ibrahim, Abouelyousr, and Jabbour (2021) to find the most significant risk factor, the severity index should be greater than 10. At the same time, Hwang, Shan, and Sup'at (2017) specified that when severity index greater than 10, the most significant level reached. Considering all above to find most significant environmental risk factors for this research, select the value of severity index is equal or greater than 10.

4.4.1 Most significant environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective

At the end of the expert interview, 37 environmental risk factors were identified to be used in questionnaire round 1. Once completed the questionnaire survey round 1 considering the frequency and impact levels, the severity index was calculated. Further the risk factors were ranked as per the severity index order and Table 4.6 elaborate the severity index as well as the rank of the risk factors which showing most significant risk factors in top.

At the same time among 37 risk factors, 11 risk factors were identified as the most significant environmental risk factors where the severity index of above were equal or more than 10.

Table 4.6: Most significant environmental risk factors in highway construction projects

Risk factor	Frequency of risk occurrence	Significant of risk impact	Severity index	Rank
Natural resources depletion in Sri Lanka like soil, sand, aggregate etc.	3.71	3.50	12.97	1
Landscape change and fragmentation	3.47	3.41	11.84	2
Disturbances for migration routes of animals	3.32	3.56	11.83	3
Floods	2.91	4.00	11.65	4
Loss of bio diversity	3.09	3.74	11.54	5
Landslides in mountainous areas	3.03	3.67	11.40	6
Disruption of physical environment	3.47	3.26	11.33	7
Loss of vegetation	3.47	3.15	10.92	8
Impacts on the natural drainage patterns and issues of irrigation water	3.21	3.32	10.65	9
Improper construction and solid waste disposal	3.15	3.29	10.37	10
Noise and vibration	3.29	3.12	10.27	11
Crop damage due to erosion	3.09	3.21	9.90	12
Ground water depletion due to large excavation, cuts and tunnels	2.79	3.50	9.78	13
Public complaints and obstruction to the work from nearby residents	3.41	2.82	9.63	14
Degradation of land due to material extraction	3.15	3.06	9.63	14
Disturbances and fragmentation of natural habitats	2.82	3.38	9.55	16
Loss of breading site	2.97	3.15	9.35	17
Not according to Ecologically sustainable development (ESD)	2.88	3.21	9.24	18
Air and water Pollution	3.32	2.76	9.19	19
Ecological damage	2.85	3.21	9.15	20
Loss of endangered and endemic flora and fauna species found in project areas	2.74	3.32	9.09	21
Non - Compliance with law and regulation for environment issue	3.00	3.03	9.09	21
Perceived Environmental impact of Project	2.97	3.03	9.00	23
Poor site conditions which not complied with EMP	2.97	3.03	9.00	23
Adverse weather conditions	2.91	3.09	8.99	25
Impact on local communities	3.12	2.88	8.99	25
Contamination of land	2.88	3.12	8.99	25
Road as habitat corridor	3.00	2.94	8.82	28
Light and sound pollution where the road cross in sanctuaries	2.88	3.00	8.65	29

Risk factor	Frequency of risk occurrence	Significant of risk impact	Severity index	Rank
Difficulty to access the site due to most sensitive areas	3.12	2.76	8.62	30
Mortality and Barriers effect to wildlife movement	2.79	3.03	8.46	31
Modification of animal behaviour	2.97	2.82	8.39	32
Changes in cropping pattern and yield loss	2.62	3.12	8.16	33
Shade effect due to via duct or large bridges	2.82	2.59	7.31	34
Introduction of chemical pollution	2.21	3.29	7.27	35
Human invasions	2.59	2.62	6.78	36
Exotic species invasions	2.18	2.85	6.21	37

The most important and significant risk factor identified by the interviewers was "*natural resources depletion in Sri Lanka like soil, sand, aggregate etc*," where it has the highest frequency level of risk occurrence and highest severity index as 12.97. Since wide variety of material required and utilized while constructing highway projects and if depletion occurred, it will be highly impacted for the successful completion of the project. Accordingly, it may cause many issues, such as shortages on supply of materials, increased in cost of materials, occurrence of soil and land degradation in related areas, requirement of extension of time as well as cost claims and cash flow issues may cause negative impact for the project. Hence, this is the most prominent environmental risk factor identified for this research.

The second risk factor identified as most significant was *landscape change and fragmentation*. Usually various kind of risk can occur in any highway construction projects due to this and mainly social issues arose via fragmentation like separation the neighbours by the high way, natural beauty of the area will be changed due to landscape changing and natural habitats of the fauna is disturbed and they will be confused by narrowing their niche.

The third most significant risk factor was *disturbances for migration routes of animals* and this is one of important environmental related risk factor, where the severity index of above was in a convenient level. Accordingly due to this risk, animals confused to find their natural trails and animals will be face unrest when their habitual routes were disturbed.

Forth most significant risk factor identified via questionnaire survey 1 was "*flood*" where it has the highest significant impact level. Arising such kind of risk crops may be damaged by the floods in the area, public properties will be damaged by the flood, people face some troubles due to flood in day to day works and project will be faced extra expenditure for compensations under flood situation.

The next important and significant risk factor to be discussed was *loss of bio diversity*, which has convenient significant impact level. Due to that the bio diversity of the area will be reduced, it will be affected to the natural balance of biological aspects and it may increase biologic imbalance in neighboring environment.

The sixth significant risk factor identified was *landslide in mountain areas* and since impact level is very high, the severity index is higher than the cut off level. Once occurred, such kind of risk, topographical stability will be changed by the landslides and surrounding people may be confused on the landslides threats.

The next risk factors identified via questionnaire survey was *disruption of physical environment* and due to that the people who living in the area may be facing some inconveniences due to physical disruptions and at the same time the project works may directly affected to the people's living style and their calmness.

The eight significant risk factor identified was *loss of vegetation* and with that, the heat/ temperature will be increased in the area due to loss of vegetation as well as the habitats will be lost in the fauna of the area.

The ninth significant risk factor was *impact on natural drainage patterns and issues of irrigation water*. Occurring this kind of risk, the natural drainage can be disturbed by the project works, it may cause to arise floods, the downstream environment will be disturbed by the changing natural water paths, Paddy fields directly affected to the drainage changes for their harvest.

Tenth risk factor identified in the severity list was *improper construction and solid waste disposal*. Accordingly, due to improper construction the surrounding community will be affected by changing usual environment, the environmental pollution will be arise due to solid waste if not remove properly as well as some strange animals may come to solid waste collecting areas.

The last significant risk factor was *noise and vibration* and due to irritable noises the public nuisance may be occurred, the public properties may be damaged by the excess vibrations and some patients may face inconvenience status due to noises.

Considering most significance risk factors, following information illustrated.

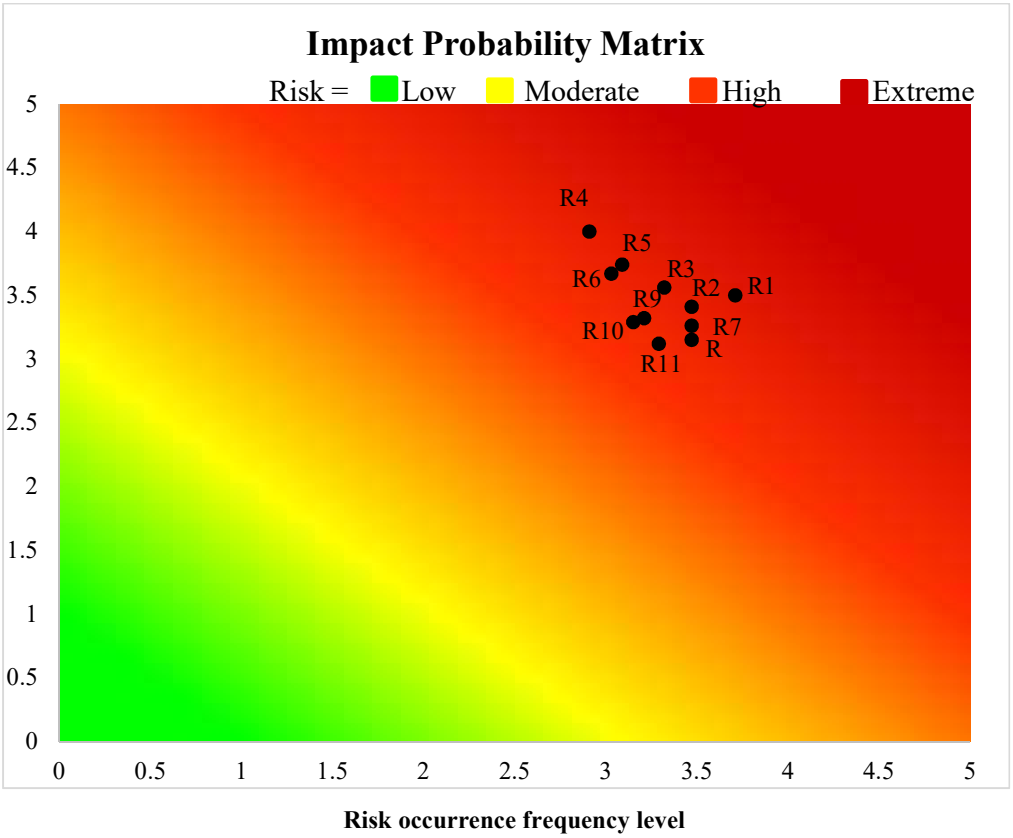

Figure 4.1: Risk matrix – Most significant environmental risk factors in highway construction projects

As per scatter diagram R1 (first most significant risk factor) giving extreme risk severity and it is in red zone of the impact probability matrix. The rest of the risk factors giving high risk severity and belongs to orange zone. The severity is the product of frequency of risk occurrence and significant of risk impact. Accordingly, figure 4.2 of histogram indicate the levels of gaps between the frequency and impacts levels considering most significant risk factors.

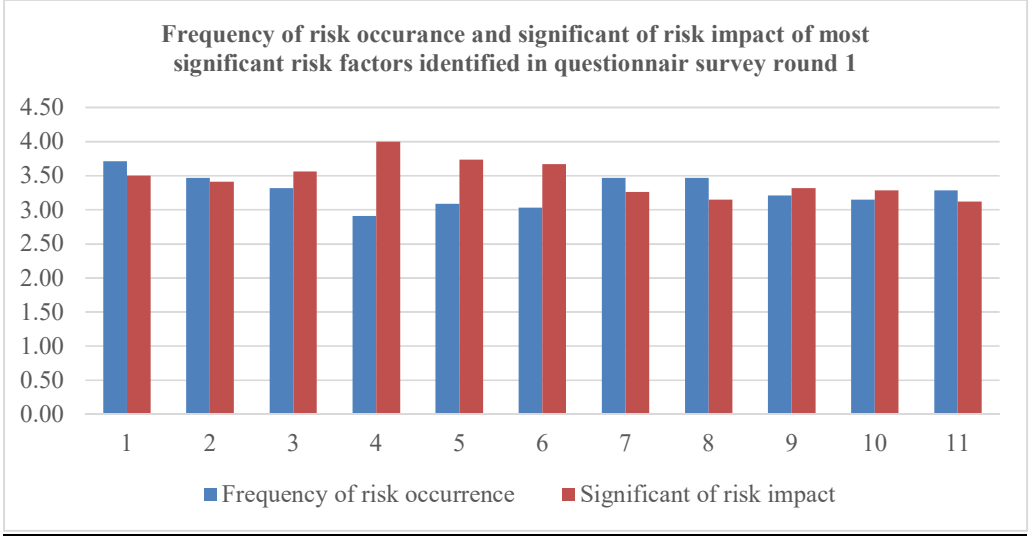

Figure 4.2: Levels of frequency of risk occurrence and significant of risk impacts

It is obvious that the risks can be significant when the level of frequency of risk occurrence or level of significant of risk impact remain low and other remain high value. Accordingly, it is observed that as specified in Table 4.6 as well as Figure 4.2, the level of frequency of risk occurrence indicated for risk factor *flood* is very low, but the risk impact has the highest value and it has the fourth level of significance among the other most significant risk factors.

Further to Table 4.6 from serial number 1 to 11, represent the most significant risk factors identified from the questionnaire round 1 and those were considered to find most suitable risk strategies (response measures) as well as risk allocated parties in questionnaire survey round 2.

4.4.2 Variance level and internal consistency - coefficient of variation (CV) and Cronbach alpha – internal consistency

Using Cronbach alpha method, the researchers can check the internal consistency of frequency level of risk occurrence and the significant of risk impact of each risk factor. When calculated, if the value of Cronbach alpha is greater than or equal 0.9, then the consistency of the each data set is "**Excellent**". According to the calculation, the Cronbach alpha for this research was **0.9527**. Hence, the selected data sample has excellent and acceptable internal consistency as described in thumb rule of Table 3.1.

4.5 Round 2 of questionnaire survey

4.5.1 Objectives of the survey round 2

The main objectives of this survey is to find most suitable risk response strategies / response measures to manage environmental risk factors in highway construction projects in Sri Lanka as well as to analyse most risk allocated parties in above projects. Finally, the most important objective is to prepare framework to manage above identified most significant environmental risk factors in highway construction projects in Sri Lanka, considering most affected contracting parties due to above risks. The data collection was done in accordance with questionnaire survey as shown in Appendix C.

4.5.2 Respondent of the survey round 2

52 questionnaires were forwarded to professionals who are having more than 5 years' experience in construction industry as well as more than 1 year experience in highway construction projects for the questionnaire survey round 2. Further, 30 expertise replied for the questionnaire and the rate of response for the survey was 58%.

6 type of professionals participated for the sharing of their experience for the questionnaire survey including environmental engineers, environmentalist, environmental officers, engineers, quantity surveyors and technical officers as summarized in Table 4.7.

Table 4.7: Profession and working experience of the respondents in questionnaire round 2

Profession	Working experience in construction industry (in years)					Working experience in highway construction projects (in years)				
	5-10	10-15	15-20	20-25	More than 25	1-5	5-10	10 - 15	15-20	**Total**
Environmental Engineer		1		1			1	1		**2**
Environmentalist	1			1		1			1	**2**
Environmental Officer	5					2	3			**5**
Engineer	7	4	2			2	7	4		**13**
Quantity Surveyor		1	2	1			1	3		**4**
Technical Officer	4					1	3			**4**

Profession	Working experience in construction industry (in years)					Working experience in highway construction projects (in years)				
	5-10	10-15	15-20	20-25	More than 25	1-5	5-10	10 - 15	15-20	**Total**
TOTAL	**17**	**6**	**4**	**3**		**6**	**15**	**8**	**1**	**30**

As specified in above table, 2 environmental engineers, 2 environmentalist, 5 environmental officers, 13 engineers, 4 quantity surveyors and 4 technical officers participated and 6 persons having 1-5 minimum experience and rest of 24 having more than minimum experience in highway construction projects in Sri Lankan contest.

4.6 Finding / Analysis of survey round 2

For the accomplishment of two main objectives, the data were collected via questionnaire round 2 and analysed. Using this, it has identified most suitable response strategies/ measures for the eleven risk factors which were selected in previous questionnaire survey and further to that identified most risk affected parties due to occurrence of above most significant environmental risk factors.

4.6.1 Most suitable environmental risk strategies / response measures to manage most significant risk factors in highway construction projects

For the second round of questionnaire survey, 34 risk response measures were selected by the interviewees coming under 4 risk response strategies; risk avoidance (RAV), risk mitigate (RMI), risk transfer (RTR) and risk acceptance (RAC) to mitigate previously identified most significant environmental risk factors. Further, the respondent were requested to select, 5 most suitable risk response measures for each risk factor. At the end of the questionnaire survey, the analysis was done for the determination of most suitable risk response strategies/ measures and highlighted as per Table 4.8 with the use of mean weighted rate calculation (MWR).

Table 4.8 indicated, the top order most suitable risk response measures against most significant risk factors identified previously via questionnaire round 1. As per the research done by Haolader, Cicioglu, and Kassim (2017), they were selected most suitable mean weighted rate as 2.5 for when consider significance of risk response measures. Further, Terano (2015) has selected 2.5 as moderately acceptable while

Mehr and Omran (2013) considered 2.5 as lower end significant level. Evaluating all above, Likert scale 2.5 has considered as most suitable cut off level for this research when selecting most suitable risk response measures.

Considering the details gathered via Table 4.8, prepared a summary to indicate how the response measures (strategies) common for most significant risk factors as indicated in Table 4.9.

Table 4.8: Most influencing environmental risk strategies / response measures

Risk factor		Strategy	Most suitable – Risk response measures	MWR	Risk factor		Strategy	Risk response measures	MWR
Natural resources depletion in Sri Lanka like soil, sand, aggregate etc.		**RMI 11**	**Introduce a point system to encourage the use of recycle material**	**3.80**	Disruption of physical environment		**RTR 2**	*Contractor can transfer the losses caused by environmental risk occurrences through insurances companies*	**2.67**
		RMI 10	**Educate project stake holders with reduce, reuse and recycle circular built environment principles in highway constructions**	**3.27**			**RAV 2**	*Done the pre crack survey before the commencement of construction works*	**2.63**
Rank	SI	**RMI 12**	**Design the highway by considering environmental effects more than the cost effectiveness**	**2.73**	Rank	SI	**RAC 6**	**Introduce crop diversification plan or provide temporary jobs for the victim farmers**	**2.57**
1	**12.97**				**7**	**11.33**	**RMI 7**	**Strictly adhere to environmental management plan**	**2.53**
Landscape change and fragmentation		**RMI 7**	**Strictly adhere to environmental management plan**	**2.97**	**Loss of vegetation**		**RAC 7**	**Introducing new forest reservations to compensate the damages to the environment**	**2.80**
		RAC 7	**Introducing new forest reservations to compensate the damages to the environment**	**2.77**			**RMI 7**	**Strictly adhere to environmental management plan**	**2.70**
Rank	SI	**RAV 4**	*Change the designs with the help of Environmental specialist for avoiding environmental risks*	**2.67**	Rank	SI	**RAC 6**	**Introduce crop diversification plan or provide temporary jobs for the victim farmers**	**2.60**
2	**11.84**	**RAV 9**	**Make EIA report approval process very strict by government authorities**	**2.57**	**8**	**10.92**	**RAV 9**	**Make EIA report approval process very strict by government authorities**	**2.53**
Disturbances for migration routes of animals		**RMI 6**	**Provide bio links, animal overpass, canopy bridges, eco duct and under passes designs**	**3.03**	**Impacts on the natural drainage patterns and issues of irrigation water**		**RMI 4**	**Mitigate improper drainage and water logging by introducing new designs such as collector drains**	**2.77**
		RMI 7	**Strictly adhere to environmental management plan**	**2.7**			**RAV 6**	**Maintain the continuity of irrigation and drainage canals/ paths within construction sites**	**2.73**
Rank	SI	**RMI 9**	**Erect meshed fences to avoid entrance of animals to highways**	**2.6**	Rank	SI	**RMI 8**	**Well maintain the natural drainage network in order to movement of the aquatic species**	**2.63**
3	**11.83**	**RAV 8**	**Erect Sign boards at the places where animals are likely to be entered**	**2.53**	**9**	**10.65**	**RAC 4**	**Perform earthworks at nearby water bodies in dry periods**	**2.53**

Risk factor		Strategy	Most suitable – Risk response measures	MWR
Floods		**RAC 5**	**Keep opening sizes of the bridges and culverts in large to free pass the flood flow**	**3.23**
		RMI 4	**Mitigate improper drainage and water logging by introducing new designs such as collector drains**	**2.73**
Rank	SI	**RAC 1**	*Develop an emergency plan and risk assessment matrix to identify severity and likelihood for expected risk factors*	**2.67**
4	**11.65**	**RAV 1**	*If the current construction activities are affected by unexpected conditions, then go for alternative construction methods*	**2.53**
Loss of bio diversity		**RMI 7**	**Strictly adhere to environmental management plan**	**2.80**
		RAV 9	**Make EIA report approval process very strict by government authorities**	**2.77**
Rank	SI	**RMI 8**	**Well maintain the natural drainage network in order to movement of the aquatic species**	**2.67**
5	**11.54**	**RMI 12**	**Design the highway by considering environmental effects more than the cost effectiveness**	**2.53**
Landslides in mountainous areas		**RAC 2**	**Employment of external specialist in case in house skills not available**	**2.83**
		RMI 3	**Involve with joint inspections, monitoring mechanisms with government regulatory bodies such as RDA, GSMB, NBRO**	**2.67**
Rank	SI	**RAC 1**	**Develop an emergency plan and risk assessment matrix to identify severity and likelihood for expected risk factors**	**2.63**
6	**11.40**	**RMI 12**	**Design the highway by considering environmental effects more than the cost effectiveness**	**2.53**

Risk factor		Strategy	Risk response measures	MWR
Improper construction and solid waste disposal		**RAV 7**	**Dump disposals in an approved location to avoid contact with terrestrial and aquatic habitats**	**3.13**
		RMI 7	**Strictly adhere to environmental management plan**	**2.70**
Rank	SI	**RMI 11**	**Introduce a point system to encourage the use of recycle material**	**2.63**
10	**10.37**	**RMI 10**	**Educate project stake holders with reduce, reuse and recycle circular built environment principles in highway constructions**	**2.50**
Noise and vibration		**RAV 3**	*Update the crack survey and maintain the records*	**2.70**
		RAV 2	*Done the pre crack survey before the commencement of construction works*	**2.67**
Rank	SI	**RMI 3**	**Involve with joint inspections, monitoring mechanisms with government regulatory bodies such as RDA, GSMB, NBRO**	**2.57**
11	**10.27**	**RTR 2**	*Contractor can transfer the losses caused by environmental risk occurrences through insurances companies*	**2.53**

New environmental risk factors identified via this research were indicated with bold letters

Environmental risk factors which modified by the interviewees were indicated with italic letters

New risk response measures which newly determined via this research were indicated with bold letters

Response measures which modified by the interviewees were indicated with italic letters

Risk response strategies (RAV – Risk avoidance, RMI – Risk mitigation, RTR – Risk transfer, RAC – Risk acceptance)

According to Table 4.8, out of 34 risk response measures 24 measures were selected to mitigate most significant environmental risk factors. At the same time, out of 24 risk response measures, 17 were new risk response measures identified via this research and those were indicated with bold letters in the table. The rest of selected 7 risk the response measures were modified by the interviewees considering highway construction projects in Sri Lankan contest and those were indicated in italic letters in above table. Further, out of 24 risk response measures 9 were risk mitigate measures (RMI), 8 were risk avoidance measures (RAV), 6 were risk acceptance measures (RAC) and 1 was risk transfer measures (RTR).

"Introduce point system to encourage the use of recycle material" was the most suitable risk response measure identified to mitigate the most significant risk factor, "*Natural resources depletion in Sri Lanka like soil, sand, and aggregate etc*.". At the same time "educate project stake holders with reduce, reuse and recycle circular built environment principles in highway constructions and design the highway by considering environmental effects more than the cost effectiveness" were the other 2 risk response measures identified by the respondents as suitable to mitigate above risk factor. Since this is most important risk factor identified by the research, we can establish a system to identify the contractors who are following above mitigation factors and give priority to them when selecting for the other projects.

Strictly adhere to environmental management plan, introducing new forest reservations to compensate the damage to the environment, change the designs with the help of Environmental specialist for avoiding environmental risks and make EIA report approval process very strict by government authorities were the selected most suitable risk response measures to mitigate the second significant risk factor, *landscape change and fragmentation*.

The next one of most convenient environmental risk factor identified was, "*disturbances for migration routes of animals"* and to mitigate above risk factor the respondent selected following response measures such as, provide bio links, animal overpass, canopy bridges, eco duct and under passes designs as well as strictly adhere to environmental management plan, erect meshed fences to avoid entrance of animals to highways and erect Sign boards at the places where animals are likely to

be entered. Meanwhile, keep opening sizes of the bridges and culverts in large to free pass the flood flow, mitigate improper drainage and water logging by introducing new designs such as collector drains as well as develop an emergency plan and risk assessment matrix to identify severity and likelihood for expected risk factors, and if the current construction activities are affected by unexpected conditions, then go for alternative construction methods were the selected most suitable 4 risk response measures by the respondent to mitigate the next significant risk factor, *flood*.

The 5th most significant risk factor identified was "*loss of bio diversity"* and to mitigate above factor respondents selected most suitable risk response measures such as; strictly adhere to environmental management plan, make EIA report approval process very strict by government authorities, well maintain the natural drainage network in order to movement of the aquatic species, and design the highway by considering environmental effects more than the cost effectiveness.

The next most significant environmental risk factor identified was "*landslides in mountain areas"*. In any construction projects, this can happen and when it happen in highway construction projects in Sri Lanka, employment of external specialist in case in house skills not available, involve with joint inspections, monitoring mechanisms with government regulatory bodies such as RDA, GSMB, NBRO, develop an emergency plan and risk assessment matrix to identify severity and likelihood for expected risk factors, and design the highway by considering environmental effects more than the cost effectiveness were the most convenient risk response measures selected by respondents.

The 7th significant risk factor identified was *disruption of physical environment* and contractor can transfer the losses caused by environmental risk occurrences through insurances companies, done the pre crack survey before the commencement of construction works, introduce crop diversification plan or provide temporary jobs for the victim farmers, and strictly adhere to environmental management plan were the most suitable 4 risk response measures for the mitigation of the said risk factor.

Then, introducing new forest reservations to compensate the damages to the environment, strictly adhere to environmental management plan, introduce crop

diversification plan or provide temporary jobs for the victim farmers, and make EIA report approval process very strict by government authorities were the most suitable risk response measures identified to mitigate the next most significant risk factor, *loss of vegetation*.

The 9th most significant risk factor was *impacts on the natural drainage patterns and issues of irrigation water* and the selected mitigation risk response measures were mitigate improper drainage and water logging by introducing new designs such as collector drains, maintain the continuity of irrigation and drainage canals/ paths within construction sites, well maintain the natural drainage network in order to movement of the aquatic species, and perform earth works at nearby water bodies in dry periods.

The next significant risk factor identified was *improper construction and solid waste disposal* and to mitigate above risk factor, the respondents selected risk response measures as dump disposals in an approved locations to avoid contact with terrestrial and aquatic habitats, strictly adhere to environmental management plan, introduce a point system to encourage the use of recycle material and educate project stake holders with reduce, reuse and recycle circular built environment principles in highway constructions.

The last and the 11th most significant risk factor identified was *noise and vibration*. Update the crack survey and maintain the records, since it is impossible to evaluate correctly, if the records are not available, done the pre crack survey before the commencement of construction works, involve with joint inspections, monitoring mechanisms with government regulatory bodies such as RDA, GSMB, NBRO, contractor can transfer the losses caused by environmental risk occurrences through insurances companies were the selected suitable risk response measures to mitigate above risk factor.

Table 4.9: Commonly used most suitable risk response strategy / response measures to manage most significant environmental risk factors

Se No	Strategy	Most suitable risk response measure	Rank of the most significant risk factor										
			1	2	3	4	5	6	7	8	9	10	11
1	RMI 7	**Strictly adhere to environmental management plan**		√	√		√		√	√		√	
2	RMI 12	**Design the highway by considering environmental effects more than the cost effectiveness**	√				√	√					
3	RAV 9	**Make EIA report approval process very strict by government authorities**		√			√			√			
4	RMI 11	**Introduce a point system to encourage the use of recycle material**	√									√	
5	RMI 10	**Educate project stake holders with reduce, reuse and recycle circular built environment principles in highway constructions**	√									√	
6	RAC 7	**Introducing new forest reservations to compensate the damage due to the environment**		√						√			
7	RMI 4	**Mitigate improper drainage and water logging by introducing new designs such as collector drains**				√					√		
8	RAC 1	*Develop an emergency plan and risk assessment matrix to identify severity and likelihood for expected risk factors*				√		√					
9	RMI 8	**Well maintain the natural drainage network in order to movement of the aquatic species**					√				√		
10	RMI 3	**Involve with joint inspections, monitoring mechanisms with Government Regulatory Bodies such as RDA, GSMB, NBRO**						√					√
11	RTR 2	*Contractor can transfer the losses caused by environmental risk occurrences through insurances companies*							√				√
12	RAV 2	*Done the pre crack survey before the commencement of construction works*							√				√
13	RAC 6	**Introduce crop diversification plan or provide temporary jobs for the victim farmers**							√	√			

1 - Natural resources depletion in Sri Lanka like soil, sand, aggregate etc., 2 - Landscape change and fragmentation, 3 - Disturbances for migration routes of animals, 4 – Floods, 5 – Loss of bio diversity, 6 – Lands slides in mountain area, 7 - Disruption of physical environment, 8 - Loss of vegetation, 9 - Impacts on the natural drainage patterns and issues of irrigation water and drainage at the paddy fields, 10 – Improper construction and solid waste disposal, 11 – Noise and vibration

New risk response measures which newly determined via this research were indicated with bold letters

Risk response strategies (RAV – Risk avoidance, RMI – Risk mitigation, RTR – Risk transfer, RAC – Risk acceptance)

Response measures which modified by the interviewees were indicated with italic letters

4.6.2 Commonly used most suitable risk response strategies / response measures to manage most significant environmental risk factors in highway construction projects

Further to Table 4.9, out of 24 risk response measures, there were 13 common risk response measures identified to manage more than 1 most significant environmental risk factors and the rest of 11 risk response measures were unique to manage each significant environmental risk factors as per analysis.

At the same time, commonly used most suitable risk response strategy/ risk response measure selected by respondents considering 11 significant risk factors is "**strictly adhere to environmental management plan**". At the same time, "**design the highway by considering environmental effects more than the cost effectiveness**, and **make EIA report approval process very strict by government authorities**" are several commonly used risk response measures selected by the respondents. Further, the 17 risk response measures which were newly identified throughout this research are unique for the highway construction projects in Sri Lankan contest.

4.6.3 Allocation of most significant environmental risk factors in highway construction projects in Sri Lanka

Further to interview, there were 3 mostly risk allocated parties identified to proceed in questionnaire survey round 2 and they were client, contractor and consultant. Accordingly, respondents were asked to indicate the percentage of risk allocation to each party as per their experience in highway construction projects in Sri Lanka.

Table 4.10 represent the allocation of risk for each party by calculation done based on average method and showing in percentage wise. According to the details gathered via literature review and interviews, there are certain ways to transfer the risks to other parties, such as transfer risk from contractor to insurance companies, transfer obligations from employer to contractor, transfer risk to other parties via contractual shifting and accordingly risk can transfer from client to contractor or from client to consultant, assign obligations under contractor's scope and employment of external specialist. Considering all above as well as with the help of survey details, it is possible to find most risk allocated party.

Table 4.10: Risk allocation to contracting parties in highway construction projects in Sri Lanka

Risk factor	Risk allocated party (% wise)		
	Client	Contractor	Consultant
Natural resources depletion in Sri Lanka like soil, sand, aggregate etc.	30.50%	**54.50%**	15.00%
Landscape change and fragmentation	**44.33%**	36.50%	19.17%
Disturbances for migration routes of animals	35.17%	**40.83%**	24.00%
Floods	27.33%	**54.17%**	18.50%
Loss of bio diversity	34.33%	**46.50%**	19.17%
Landslides in mountainous areas	25.17%	**53.00%**	21.83%
Disruption of physical environment	25.44%	**56.61%**	17.94%
Loss of vegetation	28.00%	**53.33%**	18.67%
Impacts on the natural drainage patterns and issues of irrigation water	29.33%	**52.83%**	17.83%
Improper construction and solid waste disposal	19.67%	**63.83%**	16.50%
Noise and vibration	13.63%	**72.67%**	13.70%

According to the above table, contractor has the major risk allocation for the most significant risk factor, *natural resources depletion in Sri Lanka like soil, sand, aggregate etc.* Since it is contractor's obligation to find required material to carried out the project, this has directly affected to contractor's work.

The next risk factor identified is, *landscape change and fragmentation* and according to the survey and comparing with other parties, the major risk allocated party is client particularly on this risk factor.

Considering the other results, the rest of all the risk factors allocated to contractor. Accordingly, out of 11 significant risk factors, 10 were allocated to contractor and which the percentage (%) was indicated with bold letters. Out of that 8 risk factors, the risk allocation to contractor is more than 50% and it was indicated via giving a colour code to above percentage (%). At the same time, the important point is consultant is the third risk allocated party in highway construction projects in Sri Lanka and the percentage of risk allocation was less than 25% for all significant risk factors.

When carried out the research, author has selected expertise for the interviews as well as questionnaire surveys, who working under contractor's organizations and considered the allocation of environmental risk factors with contractor's perspective.

Further to research outcomes, the majority of most significant environmental risk factors allocated to contractor, as well as contractor is the critical risk allocated party since construction works allocated to him. Hence, considering all above, obviously the risk should be allocated to contractor.

4.7 Pattern machine of this research

Further to that this provides a pattern machine showings the gaps via comparing and indicating difference between the literature and the research findings. Accordingly, the detail elaboration provides better understanding mainly about most significant environmental risk factors as well as risk strategies (risk response measures) in highway construction projects in Sri Lanka which were identified via literature review and research findings.

4.7.1 Significant environmental risk factors identified in highway construction projects in Sri Lanka

According to the Table 4.11, several most significant environmental risk factors identified through the literature review as well as some were identified via literature review and modified by the interviewers considering highway construction projects in Sri Lanka. Further new risk factors were identified by the interviewers according to their experience in highway construction projects. Table 4.11 indicated the gap between research outcome and the literature findings for the most significant risk factors which were resulted against the questionnaire survey 1.

Table 4.11: Most significant environmental risk factors in highway construction projects in Sri Lanka

Risk factor	A	B	C	D	E	F	G	Significant order
Risk factors identified via literature review and selected as environmental related risk factors								
Landscape change and fragmentation	√							**2**
Landslides in mountainous areas		√						**6**
Risk factors identified via literature review and modified as discussed with expert interviewers and selected as environmental risk factors								
Noise and vibration	√							**11**
Disruption of physical environment	√	√	√	√				**7**
Floods					√	√		**4**

Risk factor	A	B	C	D	E	F	G	Significant order
Improper construction and solid waste disposal						√	√	**10**
Natural resources depletion in Sri Lanka like soil, sand, aggregate etc.	√							**1**
Newly identified environmental risk factors throughout expert's interviews and selected as most significant via research outcome								
Disturbances for migration routes of animals								**3**
Loss of bio diversity								**5**
Loss of vegetation								**8**
Impacts on the natural drainage patterns and issues of irrigation water and drainage at the paddy fields								**9**
A - Coffin (2007), B – Alamgir et al. (2017), C - Trombulak and Frissell (2000), D - Laurance and Gomez (2005), E - Kishan, Bhavsar, and Bhatt (2014), F - Maria-Sanchez (2004), G – Walimuni et al. (2017)								

Landscape change and fragmentation was one of most significant environmental risk factor directly used for this research via literature review which was identified by Coffin (2007). *Landslides in mountainous areas* was the next most significant risk factor directly used for this research and it is a direct environmental risk factor specified by Alamigir et al. (2017).

The next environmental risk factor identified via literature review was "*noise and other atmospheric effects"* specified by Coffin (2007). Since this is common for any construction projects, it was modified to Sri Lankan contest by interviewees and convert as *noise and vibration* and selected as significant environmental risk factor via questionnaire survey 1. The next one of most significant risk factor selected as *disruption of physical environment* and it was amalgamated by interviewees and the meaning of that was previously disclosed by several authors, Alamigir, et al. (2017), Coffin (2007), Laurance and Gomez (2005) and Trombulak and Frissell (2000).

Further to that, the next most significant risk factor identified was "*flood*" and this was modified by the interviewees according to their experience in highway construction projects and several meanings has covered via this risk factor which were identified in literature previously. "*Floods, earthquake, etc., emergencies* were the previous risk factors identified by Kishan, Bhavsar, and Bhatt (2014) as well as Maria-Sanchez (2004) and since the earthquake has not experience much in Sri Lanka as elaborated by the interviewees, it has not considered accordingly.

Maria-Sanchez (2004) and Walimuni, et al. (2017), identified, "*waste management and disposal, solid and liquid waste*" as two risk factors which were common for any construction project and further discussion had with interviewees, they modified this as "*improper construction and solid waste disposal"* and selected as significant risk factor via questionnaire survey 1.

Natural resources depletion in Sri Lanka like soil, sand, aggregate etc., was identified as most significant environmental risk factor in this research. Coffin (2007) also identified this as environmental risk factor and specified as "*use of raw materials and natural resources*". Further to the discussion had with interviewees, they modified this factor considering Sri Lankan contest.

The rest of 4 factors newly identified as environmental risk factors throughout expert's interviews and selected as most significant risk factors via research outcome.

4.7.2 Most suitable environmental risk handling strategies/ response measures identified in highway construction projects in Sri Lanka

When compared with the risk response strategies/ response measures found in the literature, there is a gap in suitable risk handling strategies/ response measures in highway construction projects in Sri Lanka. Further, the research findings bridged this gap as well as provide new risk response measures considering environmental risk factors identified via the study.

Table 4.12: Most suitable risk handling strategies/ response measures in highway construction projects in Sri Lanka

Code	Most suitable risk handling strategy/ response measure	Literature reference
Response measures identified via literature review and modified as discussed with expert interviewees and used for the research		
RTR 2	*Contractor can transfer the losses caused by environmental risk occurrences through insurances companies*	Perera, et al. (2009); Yoon et al. (2015)
RAV 1	*If the current construction activities are affected by unexpected conditions, then go for alternative construction methods*	Wang and Chou (2003); Yoon et al. (2015)
RAV 2	*Done the pre crack survey before the commencement of construction works*	Perera, et al. (2009)
RAV 3	*Update the crack survey and keep the records*	
RAV 4	*Change the designs with the help of Environmental specialist for avoiding environmental risks*	Ahmadi et al. (2015); Ashley et al. (2006); Wang and Chou (2003)

Code	Most suitable risk handling strategy/ response measure	Literature reference
RAC 1	*Develop an emergency plan and risk assessment matrix to identify severity and likelihood for expected risk factors*	Yoon et al. (2015)
RAC 2	*Employment of external specialist in case in house skills not available*	Perera, et al. (2009)
Newly identified response measures throughout expert interviewees and used as research findings		
RAV 6	Maintain the continuity of irrigation and drainage canals/ paths within construction sites	
RAV 7	Dump disposals in an approved locations to avoid contact with terrestrial and aquatic habitats	
RAV 8	Erect sign boards at the places where animals are likely to be entered	
RAV 9	Make EIA report approval process very strict by government authorities	
RAC 4	Perform earthworks at nearby water bodies in dry periods	
RAC 5	Keep opening sizes of the bridges and culverts in large to free pass the flood flow	
RAC 6	Introduce crop diversification plan or provide temporary jobs for the victim farmers	
RAC 7	Introducing new forest reservations to compensate the damages to the environment due to project activities	
RMI 3	Involve with joint inspections, monitoring mechanisms with Government Regulatory Bodies such as RDA, GSMB, NBRO	
RMI 4	Mitigate improper drainage and water logging by introducing new designs such as collector drains	
RMI 6	Provide bio links, animal overpass, canopy bridges, eco duct and under passes designs	
RMI 7	Strictly adhere to environmental management plan	
RMI 8	Well maintain the natural drainage network in order to movement of the aquatic species	
RMI 9	Erect meshed fences to avoid entrance of animals to highways	
RMI 10	Educate project stake holders with reduce, reuse and recycle circular built environment principles in highway constructions	
RMI 11	Introduce a point system to encourage the use of recycle material	
RMI 12	Design the highways by considering environmental effects more than the cost effectiveness	
RAV – Risk avoidance, **RMI** – Risk mitigation, **RTR** – Risk transfer, **RAC** – Risk acceptance		

According to the literature Perera, et al. (2009) and Yoon et al. (2015), specified that "**the contractors can transfer the financial losses occurred due to all risk events through insurance companies**" and further to discussion had with interviewees that was modified according to highway construction projects in Sri Lanka and selected as suitable response measure under RTR 2. Further, this response measure proposed to mitigate two important most significant risk factors such as; "*disruption of physical environment* as well as *noise and vibration*".

Before modified the response measure RAV 1 as research outcome, Wang and Chou (2003) and Yoon et al. (2015), declare that "**if the current construction activities are affected then contractor can go for an alternative construction method to keep the construction schedule alive**". At the same time, this response measure RAV 1 selected as unique option to mitigate significant risk factor "*flood*".

Further to that two response measures RAV 2 and RAV 3 were disclose in 2009 by Perera, Dhanasinghe, and Rameezdeen and those two strategies were selected as most suitable risk response measures to mitigate most significant environmental risk factors in the research. Accordingly, RAV 2 selected as common strategy to mitigate two risk factors "*disruption of physical environment* as well as *noise and vibration*". At the same time, RAV 3 selected to mitigate the "*noise and vibration*" as a unique solution.

Wang and Chou (2003), Ashley et al. (2006) and Ahmadi et al. (2015) proposed to "**changed the plans as well as designs to avoid risks**" to mitigate risks in construction industry. Further to discussion had with interviewees, modified this response measure considering highway construction projects in Sri Lanka and categorized under RAV 4. Further this was selected as a unique solution to mitigate most significant environmental risk factor "*landscape change and fragmentation*".

"**Develop an emergency plan in case any risk event has been occurred**" was the next response measure identified via the literature review as disclosed by Yoon et al. (2015) and this was modified according to Sri Lanka contest and categorized under RAC 1. Further, the risk response measure RAC 1 proposed as common mitigation method to resolve the significant environmental risk factors, *flood* and *landslides in mountain areas*.

The other risk response measure identified via literature review was "**employment of specialist from outside in case in house skills not available**" and this was proposal of Perera, et al. (2009) as a risk response strategy for construction industry in commonly. Further to interviews, this was modified and named as RAC 2 and used in questionnaire round 2. Further this was proposed as unique risk response measure to mitigate most significant risk factor, *landslides in mountainous areas*.

As research outcome, there were 17 suitable risk handling strategies (risk response measures) newly identified by the researchers as specified in Table 4.12 under "**Newly identified response measures throughout expert interviewees and used as findings of research**". Those risk response measures are unique for the highway construction projects in Sri Lanka and able to use as most suitable risk response

strategies/ response to mitigate most significant risk factors as well as those are not readily available in the literature.

4.7.3 The risk allocation party in highway construction projects in Sri Lanka

It is obvious that the construction projects are involve with numerous risk as specified in literature. At the same time, it is not possible to eliminate the associated risk completely in any project. The best way to handle the risk is allocate the risk to different contracting parties at first and then use appropriate risk handling strategies as well as related risk response measures to mitigate above risks. Alkhamali (2014) clearly specified that unclear risk allocation is one of main dispute identified when resolving issues. According to Goh and Abdul-Rahman (2013) to control the risk in any kind of a project, well defined contract document is one of the ideal solution. Accordingly, the clients can allocate the risk via the contract documents to other contracting parties.

According to study done by Loosemore and McCarthy (2008), it was found 5 risk allocated contracting parties, such as client, contractor, consultant, sub-contractor and supplier. Referring to literature as specified in Table 4.4 (Most risk allocated parties) there were 9 risk allocated parties identified. When conducting this research, the interviewers confirmed when engaged in highway construction projects in Sri Lanka, mainly 3 contracting parties suffered due to environmental risk, such as client, contractor and consultant.

Further to literature various researchers such as; Hanna, Swanson and Aoun, (2014), Hiyassat, Alkasagi, El-Mashaleh, and Sweis, (2020), Tembo-Silungwe and Khatleli (2017) and Wang and Chou (2003), elaborated that in the construction industry mainly risk can be allocated to contractor and client. The research findings also confirmed the above statement and as per the research records the main risk allocated two parties are contractor and client in highway construction projects in Sri Lanka. At the same time research verified consultant as the third risk allocated party according to finding of the research.

Finally according the research finding, the most risk allocated party considering environmental risk factors when constructing highway construction projects in Sri Lanka is "**Contractor**".

4.7.4 Framework for management of environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective

To manage environmental risk factors in highway construction projects herewith suggested a convenient framework considering all above information and outcomes gathered via data analysis and showed in Figure 4.3. It has addressed all issues identified throughout the research and accordingly this can be used as framework for the management of environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective.

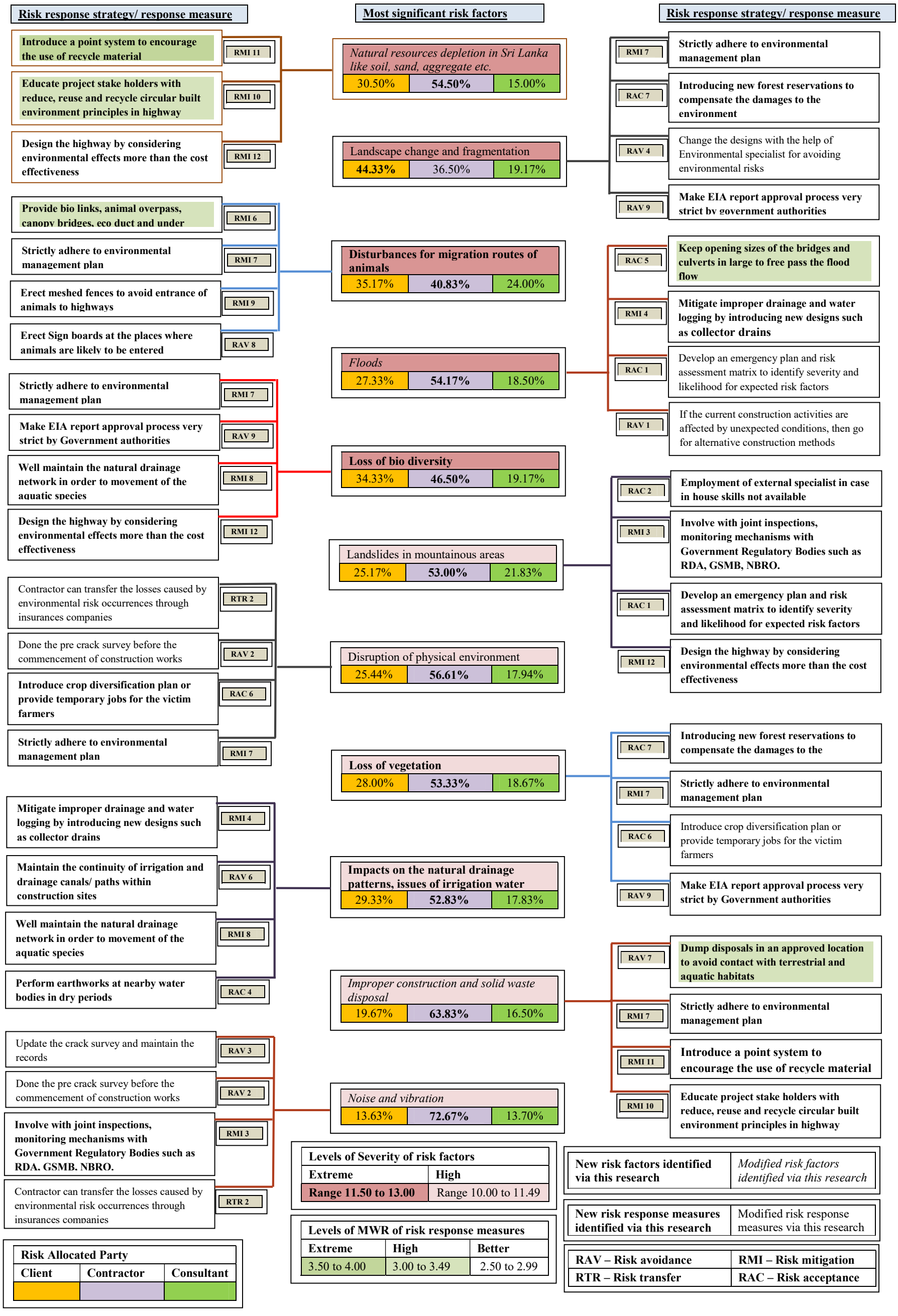

Figure 4.3: Risk management framework - Management of environmental risk factors in highway construction projects in Sri Lanka with Contractor's perspective

According to above figure, the framework highlights most significant environmental risk factor and related risk response measures as well as risk management strategies. The colour code has given considering the severity of most significant risk factor via categorizing range from 11.50 to 13.00 as "**Extreme**" and range from 10.00 to 11.49 as "**High**". At the same time new risk factors which identified via this research indicated in "**bold letters**" as well as risk factors modified as per the discussion had with interviewees indicated in "**italic letters**". Further, considering the mean weighted rate (MWR) colour code has given for the suitable risk response measures categorizing the range from 3.50 to 4.00 as "**Extreme**" and from 3.00 to 3.49 as "**High**" as well as from 2.50 to 2.99 as "**Better**". The new risk response measures which identified via this research indicated in "**bold letters**" as well as risk response measures modified as per the discussion had with interviewees indicated in "**normal letters**". Meantime, 3 risk allocated parties identified via this research and those were indicated in the framework via providing a colour code and indicated risk allocated percentage for each party as well as bolded the highest percentage according to the research findings. Accordingly this framework provides a better understanding about most significant environmental risk factors, most suitable risk response measures and related risk management strategy to mitigate above environmental risk factors and highest risk allocated party in highway construction projects in Sri Lanka.

4.8 Summary

This chapter included with the outcomes gathered via interviewers as well as two rounds of questionnaire surveys data. The literature gatherings were validated from the support of expertise who are having experience in highway construction projects and considered in questionnaire surveys in order to get the final outcomes. Further to discussion had with expertise, they have validated some literature findings as it is, some were modified considering their experience in highway construction projects and introduce new attributes to carry out the research. Based on above data the questionnaire surveys carried out and accordingly a convenient framework has designed enabling the contracting parties to use in future projects. At the same time

each outcomes were compared with the literature and discussed in detailed. The next chapter provides summaries of results as well as the recommendations.

CONCLUSION AND RECOMMENDATIONS CHAPTER 5

5.1 Introduction

Out of the risks types that environmental risks are one of the salient risks which need to be addressed especially in highway construction projects. Inconveniences will arise for the contractors especially when meeting the agreed conditions. Studies which are specifically addressing environmental risks in highway constructions projects are less in the global context. Especially, there is a dearth of literature regarding the environmental risks in Sri Lanka. Hence, with a developing framework to manage environmental risk factors in highway construction projects in Sri Lanka, coupled with contractor's perspective will address this research gap. To fulfil the aim and objectives, it was adopted mixed approach method. Further, to collect the required data expert interview as well as questionnaire survey have been carried out in two rounds. Considering the research results, it was derived a suitable framework to manage the environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective. Ultimately, conclusion, recommendations regarding the objective of the study were formulated. Further, contribution of the research limitations and areas for future studies were proposed.

5.2 Conclusions

The relevant information for the current research and the gaps were identified with the help of literature survey. Before the analysis, used research findings, expert's interviews as well as questionnaire survey to accomplish the research goals and the objectives. The research was consist with five chapters and each chapter described how the researcher achieved the required targets by fulfilling requirements of aim and objectives and this chapter elaborate overall summary.

5.2.1 Objective 1 - Identify the environmental risk factors related to highway construction projects

With the help of literature review and expert's interview, above objective was achieved. Using literature review, 41 number of risk factors were collected in

generally. After the discussion had with the expertise, 09 risk factors validate as environmental risk factors and 08 number of factors modified according to applicability of Sri Lankan contest. At the same time, 04 number of factors amalgamated with 02 modified risk factors and 17 risk factors covered with 05 risk factors. Further, 03 risk factors were removed from the list since they were not valid for Sri Lankan contest. At the same time, 13 risk factors identified newly at the interview. Accordingly, altogether 37 environmental risk factors were identified via expert interview related to highway construction projects and carried out the questionnaire survey round 1.

5.2.2 Objective 2 - Evaluate the most significant environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective

The environmental risk factors identified through literature review as well as interviews were rank considering the severity index via questionnaire round 1. The severity index was calculated considering the frequency level and the significance of each risk factor and 11 risk factors were selected for the next round of questionnaire survey where the severity index was equal to 10 or more than 10. The selected 11 most significant environmental risk factors were; Natural resources depletion in Sri Lanka like soil, sand, aggregate etc., landscape change and fragmentation, disturbances for migration routes of animals, floods, loss of bio diversity, landslides in mountainous areas, disruption of physical environment, loss of vegetation, impacts on the natural drainage patterns and issues of irrigation water, improper construction and solid waste disposal, noise and vibration. Accordingly those were carried forward to conduct the questionnaire round 2 to achieve the rest of the objectives.

5.2.3 Objective 3 – Propose the risk response strategies/ response measures to manage above identified most significant environmental risk factors by contractors

As per findings in research, mainly under 4 types of risk response strategies, there were 34 risk response measures were identified to manage environmental risk factors in highway construction projects in Sri Lanka. Further to outcomes of questionnaire round 2, there were 24 most suitable risk response measures

determined and out of that 17 were new response measures and rest of others were modified by the interviewers. Further, out of 24 risk response measures, there were 13 common risk response measures determined to mitigate more than 1 most significant environmental risk factors such as; strictly adhere to environmental management plan, design the highway by considering environmental effects more than the cost effectiveness, make EIA report approval process very strict by government authorities, introduce a point system to encourage the use of recycle material, educate project stake holders with reduce, reuse and recycle circular built environment principles in highway constructions, introducing new forest reservations to compensate the damage due to the environment, mitigate improper drainage and water logging by introducing new designs such as collector drains, develop an emergency plan and risk assessment matrix to identify severity and likelihood for expected risk factors, well maintain the natural drainage network in order to movement of the aquatic species, involve with joint inspections, monitoring mechanisms with Government Regulatory Bodies such as RDA, GSMB, NBRO, contractor can transfer the losses caused by environmental risk occurrences through insurances companies, done the pre crack survey before the commencement of construction works, introduce crop diversification plan or provide temporary jobs for the victim farmers. Beyond that rest of 11 risk response measures were unique to mitigate each significant environmental risk factors such as; change the designs with the help of environmental specialist for avoiding environmental risks, provide bio links, animal overpass, canopy bridges, eco duct and under passes designs, erect meshed fences to avoid entrance of the animals, erect sign boards at the places where animals are likely to be entered, keep opening sizes of the bridges and culverts in large to free pass the flood flow, if the current construction activities are affected by unexpected conditions, then go for alternative construction methods, employment of external specialist in case in house skills not available, maintain the continuity of irrigation and drainage canals/ paths within construction sites, perform earth works at nearby water bodies in dry periods, dump disposals in an approved locations to avoid contact with terrestrial and aquatic habitats, update the crack survey and maintain the records.

5.2.4 Objective 4 – Analyze the allocation of significant environmental risk factors

Analyse the risk allocation of significant environmental risk factors is the next objective of the research. Further to literature review and expert interviews, 3 risk allocated contracting parties were identified such as; client, contractor and consultant. Considering response received via questionnaire round 2, most of the significant environmental risk factors were allocated to contractor. Out of 11 most significant risk factors, 10 risk factors were directly allocated to contractor except the environmental risk factor; landscape change and fragmentation. At the same time, out of 10 risk factors for 8 risk factors, the risk allocation percentage (%) for the contractor is more than 50%. Further to research outcomes, the majority of most significant environmental risk factors allocated to contractor as well as contractor is the critical risk allocated party since construction works allocated to him.

5.2.5 Objective 5 – Develop a framework to manage environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective

To manage the environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective considering the scope and limitations a risk management framework was developed. The frame work convenient to be used for ongoing projects as well as for future projects.

5.3 Recommendations

Highway construction projects are very essential to minimize transportation cost, travel time as well as it has provided solutions for high traffic flows in Sri Lanka. Further, the highway construction projects are geographically spread in a wider range as well as very complex and the requirements of construction materials are very high. Comparing with other projects the risk involvement in highway project is very high as well as not like other risks, the environmental impacts are very crucial in high way construction projects. In order to address the environmental risk in highway construction projects, the given risk management framework provides a better guideline with suitable risk response strategies and relevant measures as well as consideration given for the risk allocation.

At the same time, the above framework can also be used in ongoing projects and proposed risk response measures are common for any type of risk which can be newly identified while engage in the project.

Further to that, it is recommended to introduce point system especially for the environmental related issues and select the contractors for the highway construction projects who are having high credible points by performing well by suitably addressing the environmental issues. At the same time, special attention should be given to the contractors who used recycle material for the construction of highway projects. At the same time, more concern should be given to environmental management plan, EIA report and should follow up monitoring mechanism with Government Regulatory Bodies such as RDA, GSMB, and NBRO.

5.4 Impact of the research

This research has contributed for two main areas; construction industry and academia. For the construction industry; the outcome of this research is to identify most significant risk factors in highway construction projects in Sri Lanka and identify most suitable risk handling strategies and related response measures with most risk allocated party between the contracting parties. Thereby this research will help to manage the environmental risk in construction industry properly and able to successfully complete the highway construction project. For academia; further, this can be used as a guide line when the researchers engage with their studies without considering the nature and the type of the projects as well as there is a dearth of literature regarding the environmental risks and environmental risk management in highway construction projects especially in Sri Lankan contest. This study will help to overcome this scarcity of literature.

5.5 Limitations

Some limitations has been considered when carried out this research. Mainly this research is limited to EPC foreign funded new highway construction projects and rehabilitation of highway projects are not considered. There was a unique feature identified in the Sri Lankan highway projects. The unique feature is that the client handed over only the initial EIA report to the contractor and the contractor's obligation is to carried out all test as well as all reports and proceed with the works

under EIA recommendations. Thus, a major portion of the responsibility of EIA is passed to the contractor in Sri Lankan contest. At the same time road rehabilitation works has not been considered and the study was limited to contractor's perspective.

Due to lesser highway projects in Sri Lanka limited expertise were participated for the 2 questionnaire surveys and only 34 and 30 expertise provide their valuable support to proceed this research. Since this is limited to new highway construction projects, the impact on road construction projects and rehabilitation projects were not counted. Further the findings of this study belongs to country specific and this can be used in any other country as a base study when conducting a research under same scenario.

5.6 Areas for further researches

Herewith proposed some research topics to be considered in further researches.

- Management of environmental risk factors in donor funded irrigation infrastructure projects in Sri Lanka.
- Adaptability of environmental risk management strategies in highway construction projects in Sri Lanka client's perspective.
- Framework to manage the financial and economic risk factors in highway construction projects in Sri Lanka; contractor's perspective.

LIST OF REFERENCES

Abbasi, G. Y., Abdel-Jaber, M. S., & Abu-Khadejeh, A. (2005). Risk analysis for the major factors affecting the construction industry in Jordan. *Emirates Journal for Engineering Research, 10*(1), 41-47. Retrieved from Microsoft Word - 5. Abbasi.doc (psu.edu)

Abd El-Karim, M. S. B. A., Mosa El Nawawy, O. A., & Abdel-Alim, A. M. (2017). Identification and assessment of risk factors affecting construction projects. *HBRC Journal, 13*(2), 202-216. Retrieved from https://doi.org/10.1016/ j.hbrcj.2015.05.001

Abd Karim, N. A., Rahman, I. A., Memmon, A. H., Jamil, N., & Azis, A. A. A. (2012, December). Significant risk factors in construction projects: Contractor's perception. In *2012 IEEE Colloquium on Humanities, Science and Engineering (CHUSER)* (pp. 351-354). IEEE. Retrieved from Significant Risk Management in Construction Projects: Contractor's Perception (psu.edu)

Adedokun, O. A., Ogunsemi, D. R., Aje, I. O., Awodele, O. A., & Dairo, D. O. (2013). Evaluation of qualitative risk analysis techniques in selected large construction companies in Nigeria. *Journal of Facilities Management, 11*(2), 123-135. Retrieved from https://doi.org/10.1108/14725961311314615

Adeleke, A. Q., Bamgbade, J. A., Salimon, M. G., & Lee, C. K. (2019). Project management performance and its influence on Malaysian building projects. *KnE Social Sciences*, 313-329.

Ahmadi, M., Behzadian, K., Ardeshir, A., & Kapelan, Z. (2017). Comprehensive risk management using fuzzy FMEA and MCDA techniques in highway construction projects. *Journal of Civil Engineering and Management, 23*(2), 300-310. Retrieved from https://doi.org/10.3846/13923730.2015.1068847

Akhtar, I. (2016). Research design. Research in social science: interdisciplinary perspectives.

Akintoye, A., Hardcastle, C., Beck, M., Chinyio, E., & Asenova, D. (2003). Achieving best value in private finance initiative project procurement. *Construction Management and Economics*, *21*(5), 461-470. Retrieved from https://doi.org/10.1080/0144619032000087285

Akintoye, A. S., & MacLeod, M. J. (1997). Risk analysis and management in construction. *International Journal of Project Management, 15*(1), 31-38. Retrieved from https://doi.org/10.1016/S0263-7863(96)00035-X

Alamgir, M., Campbell, M. J., Sloan, S., Goosem, M., Clements, G. R., Mahmoud, M. I., & Laurance, W. F. (2017). Economic, socio-political and environmental risks of road development in the tropics. *Current Biology, 27*(20), 1130-1140. Retrieved from https://doi.org/10.1016/j.cub.2017.08.067

Albogamy, A., & Dawood, N. (2015). Development of a client-based risk management methodology for the early design stage of construction processes: applied to the KSA. *Engineering, Construction and Architectural Management*, 22(5), 493-515. Retrieved from https://doi.org/10.1108/ECAM-07-2014-0096

Alkhamali, K. S. H. (2014). *Leadership style*, *organisational culture and disputes in public construction* (Doctoral dissertation, Heriot-Watt University).

Al-Kharashi, A., & Skitmore, M. (2009). Causes of delays in Saudi Arabian public sector construction projects. *Construction Management and Economics, 27*(1), 3-23. Retrieved from https://doi.org/10.1080/01446190802541457

Al-Shibly, H. H., Louzi, B. M., & Hiassat, M. A. (2013). The impact of risk management on construction projects success from the employees' perspective. *Interdisciplinary Journal of Contemporary Research in Business, 5*(4), 12-43.

Ametepey, S. O., & Ansah, S. K. (2014). Impacts of construction activities on the environment: the case of Ghana. *Journal of Construction Project Management and Innovation, 4*(sup-1), 934-948. Retrieved from https://hdl.handle.net/10520/EJC162729

Ameyaw, E. E., & Chan, A. P. (2015). Evaluation and ranking of risk factors in public–private partnership water supply projects in developing countries using fuzzy synthetic evaluation approach. *Expert Systems with Applications, 42*(12), 5102-5116. Retrieved from https://doi.org/10.1016/j.eswa.2015.02.041

Amirrudin, M., Nasution, K., & Supahar, S. (2021). Effect of Variability on Cronbach Alpha Reliability in Research Practice. *Journal Matematika, Statistika Dan Komputasi, 17*(2), 223-230. Retrieved from https://doi.org/10.20956/ jmsk.v17i2. 11655

Andi. (2006). The importance and allocation of risks in Indonesian construction projects. *Construction Management and Economics, 24*(1), 69-80. Retrieved from https://doi.org/10.1080/01446190500310338

Annual Report of Ministry of Finance, Sri Lanka. (2019).

Arunplod, C. (2019). A social encouragement in risk awareness using volunteered geographic information and scenario-based analysis. *Arunplod, C.(2019). A social encouragement in risk awareness using volunteered geographic information and scenario-based analysis. Journal of Advanced Research in Social Sciences and Humanities, 4*(6), 232-238. DOI:10.26500/jarssh-04-2019-0605

Ashley, D. B., Molenaar, K. R., & Diekmann, J. E. (2006). *Guide to risk assessment and allocation for highway construction management* (No. FHWA-PL-06-032). United States. Federal Highway Administration. Office of International Programs. (Report)

Ashworth, A. (1996), Pre-*Contract Studies: Development Economics, Tendering and Estimating*, Addision Wesley Longman Limited., England. Retrieved from http://dl.lib.uom.lk/handle/123/17136

Association for Project Management. (2000). Project Management Body of Knowledge, 4th edition, Project Risk Analysis and Management, a guide by APM. Retrieved from https://doi.org/10.1016/S0263-7863(99)00068-X

Ayyub, B. M. (2003). *Risk analysis in engineering and economics*. Chapman and Hall/CRC. Retrieved from https://doi.org/10.1201/9780203497692

Azis, A. A. A., Memon, A. H., Rahman, I. A., Latif, Q. B. A. I., & Nagapan, S. (2012, September). Cost management of large construction projects in South Malaysia. In 2012 IEEE Symposium on Business, Engineering and Industrial Applications (pp. 625-629). DOI: 10.1109/ISBEIA.2012.6422964

Badalpur, M., & Nurbakhsh, E. (2021). An application of WASPAS method in risk qualitative analysis: A case study of a road construction project in Iran. *International Journal of Construction Management, 21*(9), 910-918. Retrieved from https://doi.org/10.1080/15623599.2019.1595354

Bahamid, R. A., & Doh, S. I. (2017, November). A review of risk management process in construction projects of developing countries. In *IOP Conference Series: Materials Science and Engineering*, *271*(1) 1-8. DOI:10.1088/1757-899X/ 271/1/012042

Baloi, D., & Price, A. D. (2003). Modelling global risk factors affecting construction cost performance. *International Journal of Project Management, 21*(4), 261-269. Retrieved from https://doi.org/10.1016/S0263-7863(02)00017-0

Barkley, A. (2017). Implementation of Risk Management in the construction industry in development country. **Dissertation proposal** – University of Birmingham. DOI: 10.13140/RG.2.2.36332.97922

Boateng, P., Ahiaga-Dagbui, D., Chen, Z., & Ogunlana, S. (2015). Modelling economic risks in megaproject construction: a systemic approach. Proceeding of the 31st Annual ARCOM Conference. 7-9 September 2015. Nottingham. Association of Researches in Construction Management. Pp. 115- 124. Retrieved from http://hdl.handle.net/10059/1331

Bunni, N. G. (2013). *The FIDIC forms of contract.* John Wiley & Sons. Retrieved from https://d1wqtxts1xzle7.cloudfront.net/53293703/The-FIDIC-Forms-of-Contract-3rd-Ed-with-cover-page.

Burnard, P., Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Analysing and presenting qualitative data. *British Dental Journal, 204*(8), 429-432. Retrieved from https://doi.org/10.1038/sj.bdj.2008.292

Carbone, T. A., & Tippett, D. D. (2004). Project risk management using the project risk FMEA. *Engineering Management Journal, 16*(4), 28-35. Retrieved from https://doi.org/10.1080/10429247.2004.11415263

Castelblanco, G., Guevara, J., Mesa, H., & Flores, D. (2020). Risk allocation in unsolicited and solicited road public-private partnerships: Sustainability and management implications. *Sustainability, 12*(11), 4478. Retrieved from https://doi.org/10.3390/su12114478

Central Bank of Sri Lanka (2019). *Annual Report*. Central Bank of Sri Lanka. Colombo.

Chaudhary, R. (2011). Environmental protection measures in planning construction operation and maintenance of national highways in India. *International Journal of Advances in Engineering Research, 2*(3), 1-11. Retrieved from http://www.ijaer.com/

Chen, J., Dong, B., Li, H., Zhang, S., Peng, L., Fang, L., ... & Li, S. (2020). Study on landscape ecological risk assessment of Hooded Crane breeding and overwintering habitat. *Environmental Research, 187*, 109649.

Chen, Z., Li, H., & Wong, C. T. (2000). Environmental management of urban construction projects in China. *Journal of Construction Engineering and Management, 126*(4), 320-324.

Chileshe, N., & Yirenkyi-Fianko, A. B. (2012). An evaluation of risk factors impacting construction projects in Ghana. *Journal of Engineering, Design and Technology*.

Chio, H., Choi, H., & Cho, J. (2004). Risk assessment methodology for underground construction projects. *Journal of Construction Engineering and Management, 13*(2), 258-272.

Coffin, A. W. (2007). From road kill to road ecology: a review of the ecological effects of roads. *Journal of Transport Geography, 15*(5), 396-406. Retrieved from https://doi.org/10.1016/j.jtrangeo.2006.11.006

Collier, P., Kirchberger, M., & Söderbom, M. (2016). The cost of road infrastructure in low-and middle-income countries. *The World Bank Economic Review, 30*(3), 522-548. Retrieved from https://doi.org/10.1093/wber/lhv037

Cooper, D., & Chapman, C. (1987). *Risk analysis for large projects: models, methods, and cases.* Chichester, UK: John Willey & Sons.

Cooper D, Grey S, Raymond G, Walker P. (2005). *Project risk management guidelines: managing risk in large projects and complex procurements*. Chippenham (UK): John Wiley & Sons, Ltd.

Creedy, G. D. (2006). Risk factors leading to cost overrun in the delivery of highway construction projects. PhD thesis, Queensland University of Technology.

Creedy, G. D., Skitmore, M., & Wong, J. K. (2010). Evaluation of risk factors leading to cost overrun in delivery of highway construction projects. *Journal of Construction Engineering and Management, 136*(5), 528-537. Retrieved from https://doi.org/10.1061/(ASCE)CO.1943-7862.0000160

Creswell, J. (2009). *Research Design: Qualitative, Quantitative and Mixed Method Approaches* (3rd ed.). Los Angeles: SAGE Publications.

Creswell, J.W. (2013). *Qualitative inquiry and research design*: *choosing among five approaches*. London. SAGE Publications.

Creswell, J. W. (2014). *Research Design: Qualitative, quantitative and mixed methods Approaches (4th Ed.)*. Thousand Oaks, CA: Sage.

Crnković, D., & Vukomanović, M. (2016). Comparison of trends in risk management theory and practices within the construction industry. *Advances in Civil and Architectural Engineering, 7*(13), 1-11. Retrieved from https://doi.org/10.13167/ 2016.13.1

Dako, W. (n.d.). (2019) An Assessment of Risk Management practices. A Case study of el-virtuees construction limited. University of Ghana http://ugspace.ug.edu.gh

Dey, P. K., & Ogunlana, S. O. (2004). Selection and application of risk management tools and techniques for build-operate-transfer projects. *Industrial Management & Data Systems, 104*(4), 334-346. Retrieved from https://doi.org/10.1108/ 02635570410530748

Dhanasinghe, I., & Perera, B. A. K. S. (2008). Risk allocation of road projects in Sri Lanka. *Building Resilience, 83*.

Diab, M. F., Varma, A., & Panthi, K. (2017). Modelling the construction risk ratings to estimate the contingency in highway projects. *Journal of Construction Engineering and Management, 143*(8), 1-8. Retrieved from https://doi.org/10.1061/ (ASCE)CO.1943-7862.0001334

Douglas, H. (2009). The failure of risk management: why it's broken and how to fix it. *(1st ed).* John Wiley & Sons, NY, 46, 271.

Dulac, J. (2013). Global land transport infrastructure requirements. Estimating road and railway infrastructure capacity and costs to 2050, Information paper, (pp. 1-54). Paris: *International Energy Agency, 20*, 2014.

Dziadosz, A., & Rejment, M. (2015). Risk analysis in construction project-chosen methods. *Procedia Engineering, 122*, 258-265. Retrieved from https://doi.org/10.1016/j.proeng.2015.10.034

Edwards, P. J., & Bowen, P. A. (1998). Risk and risk management in construction: a review and future directions for research. *Engineering Construction and Architectural Management, 5*(4), 339-349. Retrieved from https://doi.org/10.1046 /j.1365-232X.1998.54072.x

Elkington, P., & Smallman, C. (2002). Managing project risks: a case study from the utilities sector. *International Journal of Project Management, 20*(1), 49-57. Retrieved from https://doi.org/10.1016/S0263-7863(00)00034-X

Elmabruk, R., & Almwber, A. (2018). Research design and methodology.

El-Sayegh, S. M. (2008). Risk assessment and allocation in the UAE construction industry. *International Journal of Project Management, 26*(4), 431-438. Retrieved from https://doi.org/10.1016/j.ijproman.2007.07.004

El-Sayegh, S. M., Manjikian, S., Ibrahim, A., Abouelyousr, A., & Jabbour, R. (2021). Risk identification and assessment in sustainable construction projects in the UAE. *International Journal of Construction Management, 21*(4), 327-336. Retrieved from https://doi.org/10.1080/15623599.2018.1536963

El-Sayegh, S. M., & Mansour, M. H. (2015). Risk assessment and allocation in highway construction projects in the UAE. *Journal of Management in Engineering, 31*(6), 1-11. Retrieved from Risk Assessment and Allocation in Highway Construction Projects in the UAE | Journal of Management in Engineering | Vol 31, No 6 (ascelibrary.org)

Enshassi, A., & Mosa J A (2015). Risk management in building projects: owners' perspective, *IUG Journal for Natural and Engineering Studies, 16*(1) 1-29. Retrieved from http://hdl.handle.net/20.500.12358/23357

Environmental Protection Department (EPD). (1999). *Environment Hong Kong annual report 1999*, Hong Kong Government, 8–15.

Everitt, B. S., & Skrondal, A. (2010). The Cambridge dictionary of statistics. Retrieved from http://196.43.179.3:8080/xmlui/handle/123456789/1213

Fang, D. L. M., Fong, P. S. W., & Shen, L. (2004). Risks in Chinese construction market-contractors' perspective. *Journal of Construction Egineering Management, 130*(6), 853-861. DOI:10.1061/(ASCE)0733-9364(2004)130:6 (853)

Fang, C., & Marle, F. (2012). A simulation-based risk network model for decision support in project risk management. *Decision Support Systems, 52*(3), 635-644. Retrieved from https://doi.org/10.1016/j.dss.2011.10.021

Flanagan, R., & Norman, G. (1993). *Risk management and construction*. Oxford: Blackwell Science Ltd.

Fok, P., Neo, B. H., Wen, D., & Veeresh, C. (2012). Design and construction of earth retaining walls for deep excavation–a risk management process. *The IES Journal Part A: Civil & Structural Engineering, 5*(3), 204-209. Retrieved from https://doi.org/10.1080/19373260.2012.696441

Gain, H., Kumar Mishra, A., & Aithal, P. S. (2022). Risk Management Practice Adopted in Road Construction Project. *International Journal of Management, Technology, and Social Sciences (IJMTS), 7*(1), 21-36. Retrieved from https://mpra.ub.uni-muenchen.de/112055/

Ghoddousi, P., & Hosseini, M. R. (2012). A survey of the factors affecting the productivity of construction projects in Iran. *Technological and Economic Development of Economy, 18*(1), 99-116. Retrieved from https://doi.org/10.3846/20294913.2012.661203

Goertzen, M. J. (2017). *Applying quantitative methods to e-book collections.* ALA Tech Source. Retrived from applying quantitative methods to e-book collections.pdf

Goh, C. S., & Abdul-Rahman, H. (2013). The identification and management of major risks in the Malaysian construction industry. *Journal of Construction in Developing Countries, 18*(1), 19-32. Retrieved from The-Identification-and-Management-of-Major-Risks-in-the-Malaysian-Construction-Industry.pdf (researchgate.net)

Gosavi, A. (2015). Analyzing Responses from Likert Surveys and Risk-adjusted Ranking: A Data Analytics Perspective. *Complex Adaptive Systems, 61*, 24-31. Retrived from Analyzing-Responses-from-Likert-Surveys-and-Risk-adjusted-Ranking-A-Data-Analytics-Perspective.pdf (researchgate.net)

Goundar, S. (2012). Research Methodology and Research Method: Methods Commonly Used By Researchers. *Victoria University of Wellington*. Retrived from https://prallagon. com/wpcontent/uploads/2021/05/Research-Methodology-A2. pdf.

Han, S. H., Kim, D. Y., Kim, H., & Jang, W. S. (2008). A web-based integrated system for international project risk management. *Automation in Construction, 17*(3), 342-356. Retrieved from https://doi.org/10.1016/j.autcon.2007.05.012

Hanna, A. S., Swanson, J. R., & Aoun, D. G. (2014). Proper risk allocation during construction: Differing site conditions. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 6*(4), 21-32. Retrieved from Proper Risk Allocation during Construction: Differing Site Conditions | Journal of Legal Affairs and Dispute Resolution in Engineering and Construction | Vol 6, No 4 (ascelibrary.org)

Haolader, F. A., Cicioglu, D., & Kassim, K. (2017). A model of technical and vocational teacher education at bachelor's degree level and its relevance to the occupational tasks of TVET teachers in the OIC member states. *TVET@ Asia,*

(8), 1-19. Retrieved from paper_2-haolader_etal_tvet820200413-20815-19c3ell-with-cover-page-v2.pdf (d1wqtxts1xzle7.cloudfront.net)

Hardcastle, C., Edwards, P. J., Akintoye, A., & Li, B. (2005). Critical success factors for PPP/PFI projects in the UK construction industry: a factor analysis approach. *Construction Management and Economics, 23*(5), 459-471. Retrieved from https://doi.org/10.1080/01446190500041537

Harwell, M. R. (2011). Research design: Qualitative, quantitative, and mixed methods: Pursuing ideas as the keystone of exemplary inquir. In *The Sage handbook for research in education: Pursuing ideas as the keystone of exemplary inquire.* Sage. Retrieved from Research design: Qualitative, quantitative, and mixed methods: Pursuing ideas as the keystone of exemplary inquir — Experts@Minnesota (umn.edu)

Hellstén, H. (2018). *Cyber risk management in the Finnish healthcare sector* (Master's thesis). Retrieved from 1518709273.pdf (1.005Mt)

Hillson, D. (2002). Extending the risk process to manage opportunities. *International Journal of Project Management, 20*(3), 235-240. Retrieved from https://doi.org/10.1016/S0263-7863(01)00074-6

Hiyassat, M. A., Alkasagi, F., El-Mashaleh, M., & Sweis, G. J. (2020). Risk allocation in public construction projects: the case of Jordan. *International Journal of Construction Management,* 1-11. Retrieved from https://doi.org/10.1080 /15623599.2020.1728605

Hoseini, E., Hertogh, M., & Bosch-Rekveldt, M. (2021). Developing a generic risk maturity model (GRMM) for evaluating risk management in construction projects. *Journal of Risk Research, 24*(7), 889-908. Retrieved from https:// doi.org/10.1080/13669877.2019.1646309

Hwang, B. G., Shan, M., & Supa'at, N. N. B. (2017). Green commercial building projects in Singapore: Critical risk factors and mitigation measures. *Sustainable*

Cities and Society, 30, 237-247. Retrieved from https://doi.org/10.1016/j.scs.2017.01.020

Hwang, B. G., Zhao, X., & Toh, L. P. (2014). Risk management in small construction projects in Singapore: Status, barriers and impact. *International Journal of Project Management, 32*(1), 116-124. Retrieved from https://doi.org/10.1016/j.ijproman. 2013.01.007

Iqbal, S., Choudhry, R. M., Holschemacher, K., Ali, A., & Tamošaitienė, J. (2015). Risk management in construction projects. *Technological and Economic Development of Economy, 21*(1), 65-78. Retrieved from https://doi.org/10.3846/20294913.2014.994582

Iramaneerat, C., Yudkowsky, R., Myford, C. M., & Downing, S. M. (2008). Quality control of an OSCE using generalizability theory and many-faceted Rasch measurement. *Advances in Health Sciences Education, 13*(4), 479-493. Retrieved from https://doi.org/10.1007/s10459-007-9060-8

Issa, U. H., Marouf, K. G., & Faheem, H. (2021). Analysis of risk factors affecting the main execution activities of roadways construction projects. *Journal of King Saud University-Engineering Sciences.* Retrieved from https://doi.org/10.1016/j.jksues. 2021.05.004

Jarkas, A. M., & Haupt, T. C. (2015). Major construction risk factors considered by general contractors in Qatar. *Journal of Engineering, Design and Technology. 13*(1), 165-194. Retrieved from https://doi.org/10.1108/JEDT-03-2014-0012

Jayasudha, K., & Vidivelli, B. (2016). Analysis of major risks in construction projects. *ARPN Journal of Engineering and Applied Sciences, 11*(11), 6943-6950. Retrieved from jeas_0616_4375.pdf (arpnjournals.org)

Jepson, J., Kirytopoulos, K., & London, K. (2020). Insights into the application of risk tools and techniques by construction project managers. *International Journal of Construction Management, 20*(8), 848-866. Retrieved from https://doi.org /10.1080/15623599.2018.1494673

Jiao, P., Zhang, H., & He, K. (2015, November). The environmental problems of highway construction. In *5th International Conference on Civil Engineering and Transportation* (pp. 1357-1360). Atlantis Press.

Kagne, R. K., & Vyas, G. S. (2020, August). Investigation and Modeling of Financial Risks Associated with PPP Road Projects in India. In *International Conference on Transportation and Development 2020* (pp. 309-318). Reston, VA: American Society of Civil Engineers. Retrieved from Investigation and Modeling of Financial Risks Associated with PPP Road Projects in India | International Conference on Transportation and Development 2020 (ascelibrary.org)

Karimi Azari, A., Mousavi, N., Mousavi, S. F., & Hosseini, S. (2011). Risk assessment model selection in construction industry. *Expert Systems with Applications, 38*(8), 9105-9111. Retrieved from https://doi.org/10.1016/j.eswa.2010.12.110

Karlson, M., & Mörtberg, U. (2015). A spatial ecological assessment of fragmentation and disturbance effects of the Swedish road network. *Landscape and Urban Planning, 134*, 53-65. Retrieved from https://doi.org/10.1016/j.landurbplan .2014.10.009

Karunasena, G., Abeydeera, L.H.U.W., Ranasinghe, U., & Pratheeban, S. (2017). Challenges in highway construction projects in Sri Lanka. Research gate. Net Article 2017. (04.04.2021) Retrieved from https://www.researchgate.net/profile/Gayani_Karunasena/publication/324490801_Challenges_in_Highway_Construction_Projects_in_Sri_Lanka/links/5ad00cd5a6fdcc87841191fb/Challenges-in-Highway-Construction-Projects-in-Sri-Lanka.pdf

Kishan, P., Bhatt, R., & Bhavsar, J. J. (2014). A study of risk factors affecting building construction projects. *International Journal of Engineering Research & Technology, 3*(12), 831-835.

Klemetti, A. (2006). Risk management in construction project networks. Retrieved from http://urn.fi/urn:nbn:fi:tkk-006304

Khodeir, L. M., & Mohamed, A. H. M. (2015). Identifying the latest risk probabilities affecting construction projects in Egypt according to political and economic variables. From January 2011 to January 2013. *HBRC Journal, 11*(1), 129-135. Retrieved from https://doi.org/10.1016/j.hbrcj.2014.03.007

Kothari, C. R. (2004). *Research methodology: Methods and techniques.* New Age International. Retrieved from Research Methodology: Methods and Techniques - C. R. Kothari - Google Books

Kuang, Z. (2011). Risk management in construction projects: Application of risk management in construction period. Bachelor of Architectural Technology and Construction Management. Via University College, Horsens Campus, Denmark.

Kululanga, G., & Kuotcha, W. (2010). Measuring project risk management process for construction contractors with statement indicators linked to numerical scores. *Engineering, Construction and Architectural Management.17*(4), 336-351. Retrieved from https://doi.org/10.1108/09699981011056556

Kumar, R. (2018). *Research methodology: A step-by-step guide for beginners* (5 th ed.). Los Angelies. Sage.

Kumar, R. P., Sheikh, A., & Asadi, S. S. (2017). A Systematic Approach For Evaluation of Risk Management In Road Construction Projects-A Model Study. *International Journal of Civil Engineering and Technology, 8*(3), 888-902. Retrieved from http://www.iaeme.com/IJCIET/index.asp

Kuo, Y. C., & Lu, S. T. (2013). Using fuzzy multiple criteria decision making approach to enhance risk assessment for metropolitan construction projects. *International Journal of Project Management, 31*(4), 602-614. Retrieved from https://doi.org/ 10.1016/j.ijproman.2012.10.003

Laurance, S. G., & Gomez, M. S. (2005). Clearing width and movements of understory rainforest birds 1. *Biotropica: The Journal of Biology and Conservation, 37*(1), 149-152. Retrieved from https://doi.org/10.1111/j.1744-7429.2005.04099.x

Laurance, W. F., & Balmford, A. (2013). A global map for road building. *Nature, 495*(7441), 308-309. Retrieved from https://doi.org/10.1038/495308a

Laurance, W. F., Clements, G. R., Sloan, S., O'connell, C. S., Mueller, N. D., Goosem, M., & Arrea, I. B. (2014). A global strategy for road building. *Nature, 513*(7517), 229-232. Retrieved from https://doi.org/10.1038/nature13717

Laurance, W. F., Goosem, M., & Laurance, S. G. (2009). Impacts of roads and linear clearings on tropical forests. *Trends in Ecology & Evolution, 24*(12), 659-669. Retrieved from https://doi.org/10.1016/j.tree.2009.06.009

Laurance, W. F., Sloan, S., Weng, L., & Sayer, J. A. (2015). Estimating the environmental costs of Africa's massive "development corridors". *Current Biology, 25*(24), 3202-3208. Retrieved from https://doi.org/10.1016/j.cub.2015.10.046

Lee, N., & Schaufelberger, J. E. (2014). Risk management strategies for privatized infrastructure projects: Study of the build–operate–transfer approach in East Asia and the Pacific. *Journal of Management in Engineering, 30*(3), 1-8. Retrieved from Risk Management Strategies for Privatized Infrastructure Projects: Study of the Build–Operate–Transfer Approach in East Asia and the Pacific | Journal of Management in Engineering | Vol 30, No 3 (ascelibrary.org)

Lewis, S. C., Zamith, R., & Hermida, A. (2013). Content analysis in an era of big data: A hybrid approach to computational and manual methods. *Journal of Broadcasting & Electronic Media, 57*(1), 34-52. Retrieved from https://doi.org/10. 1080/08838151.2012.761702

Liu, B. (2010). Uncertain risk analysis and uncertain reliability analysis. *Journal of Uncertain Systems, 4*(3), 163-170. Retrieved from http://orsc.edu.cn/liu.

Liu, J., Li, B., Lin, B., & Nguyen, V. (2007). Key issues and challenges of risk management and insurance in China's construction industry: An empirical study. *Industrial Management & Data Systems, 107*(3), 382-396. Retrieved from https://doi.org/10.1108/02635570710734280

Liu, J., Zhao, X., & Yan, P. (2016). Risk paths in international construction projects: Case study from Chinese contractors. *Journal of Construction Engineering and Management, 142*(6), 1-9. Retrieved from https://doi.org/10.1061/(ASCE)CO.1943-7862.0001116

Loosemore, M., & McCarthy, C. S. (2008). Perceptions of contractual risk allocation in construction supply chains. *Journal of Professional Issues in Engineering Education and Practice, 134*(1), 95-105. Retrieved from https://doi.org/10.1061/(ASCE)1052-3928(2008)134:1(95)

Madushika, W. H. S., Perera, B. A. K. S., Ekanayake, B. J., & Shen, G. Q. P. (2020). Key performance indicators of value management in the Sri Lankan construction industry. *International Journal of Construction Management, 20*(2), 157-168. Retrieved from https://doi.org/10.1080/15623599.2018.1484556

Mann, D., Anees, M. M., Rankavat, S., & Joshi, P. K. (2021). Spatio-temporal variations in landscape ecological risk related to road network in the Central Himalaya. *Human and Ecological Risk Assessment: An International Journal, 27*(2), 289-306. Retrieved from https://doi.org/10.1080/10807039.2019.1710693

Maria-Sanchez, P. (2004). Estimation of environmental risks in construction projects in Puebla (Mexico): a neural network approach. *WIT Transactions on Ecology and the Environment, 77(2),* 603-612. Retrieved from RISK04055FU.pdf

Martins, A. (2011) *Gestão de Riscos em Obras de Construção Civil.* (Master Thesis in Civil Engineering, University of Trás-os-Montes and Alto Douro - UTAD), Vila Real, Portugal, pp. 100.

Mehr, S. Y., & Omran, A. (2013). Examining the challenges affect on the effectiveness of materials management in the Malaysian construction industry. *International Journal of Academic Research, 5*(2), 56-63. DOI: 10.7813/2075-4124.2013/5-2/A.7

Merna, T., Chu, Y., & Al-Thani, F. F. (2010). *Project finance in construction: A structured guide to assessment (*1st ed.). University of Manchaster. John Wiley & Sons.

Mhetre, K. V., Wagh, Y. D., Bhujbal, A. D., Patil, S. M., & Ranaware, A. N. (2019). Risk Management of Construction Projects by using Primavera Risk Analysis. *6*(5), 1639-1642. Retrieved from IRJET-V6I532820190706-48198-lpw6bo-with-cover-page-v2.pdf (d1wqtxts1xzle7.cloudfront.net)

Mills, A. (2001). A systematic approach to risk management for construction. *Structural Survey. 19*(5), 245-252. Retrieved from https://doi.org/10.1108/02630800110412615

Mishra, A. K., & Mallik, K. (2017). Factors and impact of risk management practice on success of construction projects of housing developers, Kathmandu, Nepal. *International Journal of Sciences: Basic and Applied Research (IJSBAR), 36*(7), 206-232. Retrieved from Factors-and-Impact-of-Risk-Management-Practice-on-Success-of-Construction-Projects-of-Housing-Developers-Kathmandu-Nepal.pdf (researchgate.net)

Mohajan, H. K. (2017). Aspects of mathematical economics, social choice and game theory: Jamal Nazrul Islam Research Centre for Mathematical Research. *Journal of Economic Development, Environment and People, March.* Retrieved from https://doi. org/10.13140/RG, 2(16589.03040)

Molenaar, K. R., & Wilson, C. R. (2009). A risk-based approach to contingency estimation in highway project development. In *Construction Research Congress 2009: Building a Sustainable Future* (pp. 786-795). Retrieved from https://doi.org/10.1061/41020(339)80

Moshood, T. D., Adeleke, A. Q., Nawanir, G., & Mahmud, F. (2020). Ranking of human factors affecting contractors' risk attitudes in the Malaysian construction industry. *Social Sciences & Humanities Open, 2*(1). Retrieved from https://doi.org/10.1016/j.ssaho.2020.100064

Myers, N., Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature, 403*(6772), 853-858. DOI: https://doi.org/10.1038/35002501

Naji, H. I., & Ali, R. H. (2017). Risk response selection in construction projects. *Civil Engineering Journal, 3*(12), 1208-1221. DOI: 10.28991/cej-030950

Naji, H. I., & Ali, R. H. (2018, January). Qualitative analysis of cost risk using WEKA program. In *2018 1st International Scientific Conference of Engineering Sciences-3rd Scientific Conference of Engineering Science (ISCES)* (pp. 271-274). IEEE. DOI: 10.1109/ISCES.2018.8340566

Neilson, W. S. (2006). Axiomatic reference-dependence in behavior toward others and toward risk. Economic Theory, 28(3), 681-692. Retrieved from https://doi.org/10.1007/s00199-005-0643-4

Nguyen, A., Mollik, A., & Chih, Y. Y. (2018). Managing critical risks affecting the financial viability of public–private partnership projects: Case study of toll road projects in Vietnam. *Journal of Construction Engineering and Management, 144*(12). Retrieved from https://doi.org/10.1061/(ASCE)CO.1943-7862.0001571

Nieto-Morote, A., & Ruz-Vila, F. (2011). A fuzzy approach to construction project risk assessment. *International Journal of Project Management, 29*(2), 220-231. Retrieved from https://doi.org/10.1016/j.ijproman.2010.02.002

Ofori, G. (1992). The environment: the fourth construction project objective?. *Construction Management and Economics, 10*(5), 369-395. Retrieved from https://doi .org/10.1080/01446199200000037

Olamiwale, I. O. (2014). *Evaluation of risk management practices in the construction industry in Swaziland*. (Master of Quantity Surveying Thesis, Tshwane University of Technology, Pretoria, South Africa).

Omopariola, E. D., Windapo, A., Edwards, D. J., & El-Gohary, H. (2021). Level of Financial Performance of Selected Construction Companies in South Africa. *Journal of Risk and Financial Management*, *14*(11), 518. Retrieved from https://doi.org/10.3390/jrfm14110518

Palliyaguru, R., Karunasena, G., & Ang, S. (2018). Review on sustainable building design and construction in the rural context: the case of building Ampara, Sri Lanka. In *Sustainable Development Research in the Asia-Pacific Region* (pp. 493-507). Springer, Cham. Retrieved from https://doi.org/10.1007/978-3-319-73293-0_29

Peckiene, A., Komarovska, A., & Ustinovicius, L. (2013). Overview of risk allocation between construction parties. *Procedia Engineering, 57*, 889-894. Retrieved from https://doi.org/10.1016/j.proeng.2013.04.113

Perera, B. A. K. S., Dhanasinghe, I., & Rameezdeen, R. (2009). Risk management in road construction: the case of Sri Lanka. *International Journal of Strategic Property Management, 13*(2), 87-102. Retrieved from https://doi.org/10.3846/1648-715X.2009.13.87-102

Perera, B. A. K. S., Samarakkody, A. L., & Nandasena, S. R. (2020). Managing financial and economic risks associated with high-rise apartment building

construction in Sri Lanka. *Journal of Financial Management of Property and Construction, 25*(1), 143-162. Retrieved from https://doi.org/10.1108/JFMPC-04-2019-0038

Perera, B. A. K. S., Rameezdeen, R., Chileshe, N., & Hosseini, M. R. (2014). Enhancing the effectiveness of risk management practices in Sri Lankan road construction projects: A Delphi approach. *International Journal of Construction Management, 14*(1), 1-14. DOI:10.1080/15623599.2013.875271

Perez, D., Gray, J., & Skitmore, M. (2017). Perceptions of risk allocation methods and equitable risk distribution: a study of medium to large Southeast Queensland commercial construction projects. *International Journal of Construction Management, 17*(2), 132-141. Retrieved from https://doi.org/10.1080/ 15623599.2016.1233087

PMI Standards Committee, & Project Management Institute. (1996). A guide to the project management body of knowledge. Project Management Institute.

PMI. (2008). *A guide to the project management body of knowledge* (3rd ed.). USA: Project Management Institute Inc.

Project Management Institution (2013). *A guide to the project management body of knowledge* (5th ed.). Newtown Square, Pennsylvania: Project Management Institute.

PMI (2017). *A Guide to the Project Management Body of Knowledge* (PMBOK guide 6th ed.). Project Management Institute.

Popvici, E., Fernando, C., & Navarrete, V. (2016). Risk response strategies in public institution. *International Conference of Science. Romania*: Lasi.

Priyantha, T. H. S., Karunasena, G., & Rodrigo, V. A. K. (2011). Causes, Nature and Effects of variations in Highways. *Built-Environment Sri Lanka, 9*(1-2). Retrieved from 3056-10647-1-PB.pdf

Punch, K. F. (2013). *Introduction to social research: Quantitative and qualitative approaches.* SAGE Publications.

Rahman, M. K. M., & Joadder, M. M. (2017). A review on the components of EEG-based motor imagery classification with quantitative comparison. *Application Theory Computed Technology, 2*(2), 1-15. DOI: 10.22496/atct20170122133

Rahimi, Y., Tavakkoli-Moghaddam, R., Iranmanesh, S. H., & Vaez-Alaei, M. (2018). Hybrid approach to construction project risk management with simultaneous FMEA/ISO 31000/evolutionary algorithms: Empirical optimization study. *Journal of Construction Engineering and Management, 144*(6). Retrieved from https://orcid.org/0000-0002-0292-9695

Rajput, B., Agarwal, A., & Yadav, S. (2020). Risk factors causing cost overrun in highway construction projects. *IUP Journal of Management Research, 19*(3), 7-22. Retrieved from Risk Factors Causing Cost Overrun in Highway Construction Projects - ProQuest

Rasool, M., Franck, T., Denys, B., & Halidou, N. (2012). Methodology and tools for risk evaluation in construction projects using Risk Breakdown Structure. *European Journal of Environmental and Civil Engineering, 16*(sup1), 78-98. Retrieved from https://doi.org/10.1080/19648189.2012.681959

Reilly, J., & Brown, J. (2004, July). Management and control of cost and risk for tunneling and infrastructure projects. In *Proceeding 30th* Ita-Aites, World Tunnel Congress Singapore. Retrieved from http://worldcat.org/issn/08867798

Renault, B. Y., & Agumba, J. N. (2016). Risk management in the construction industry: A new literature review. In *MATEC web of conferences* (Vol. 66, pp. 1-8). EDP Sciences. Retrieved from https://doi.org/10.1051/matecconf/20166600008

Rezakhani, P. (2012). Classifying key risk factors in construction projects. *Buletinul Institutului Politehnic din lasi. Sectia Constructii, Arhitectura, 58*(2), 27.

Road Development Authority - Sri Lanka (RDA) 2016

Road Development Authority - Sri Lanka (RDA) 2020, (accessed 2020 November 26) Retrieved from http://www.rda.gov.lk/source/project_details.htm

Rostami, A., & Oduoza, C. F. (2017). Key risks in construction projects in Italy: Contractors' perspective. *Engineering, Construction and Architectural Management, 24*(3), 451-462. Retrieved from https://doi.org/10.1108/ECAM-09-2015-0142

Saleem, H., Sajid, A., Aftab, R., & Malik, Z. (2021). A Journey to Cherish; How Transformational Leadership Affects Project Success through Team Performance. *Psychology and Education, 58*(1), 1156-1166. Retrieved from A-Journey-to-Cherish-How-Transformational-Leadership-Affects-Project-Success-through-Team-Performance.pdf (researchgate.net)

Sato, Y., Kitazume, K., & Miyamoto, K. (2005). Quantitative risk analysis of road projects based on empirical data in Japan. *Journal of the Eastern Asia Society for Transportation Studies, 6*, 3971-3984. Retrieved from https://doi.org/10.11175 /easts.6.3971

Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research methods for business students* (6th ed.). Pearson Education.

Schatteman, D., Herroelen, W., Van de Vonder, S., & Boone, A. (2008). Methodology for integrated risk management and proactive scheduling of construction projects. *Journal of Construction Engineering and Management, 134*(11), 885-893. Retrieved from https://doi.org/10.1061/(ASCE)0733-9364(2008)134:11(885)

Serpella, A. F., Ferrada, X., Howard, R., & Rubio, L. (2014). Risk management in construction projects: a knowledge-based approach. *Procedia-Social and Behavioral Sciences, 119*, 653-662. Retrieved from https://doi.org/10.1016/j.sbspro.2014.03.073

Sharaf, M. M. M., & Abdelwahab, H. T. (2015). Analysis of risk factors for highway construction projects in Egypt. *Journal of Civil Engineering and Architecture, 9*(12), 526-533.

Sharkey, J. J., Bell, M., Jocic, W., & Marginean, R. (2014). *Standard forms of contract in the Australian construction industry*. Melbourne: Law School.

Sharma, S., & Gupta, A. K. (2019). Risk identification and management in construction projects: Literature review. *International Journal of Humanities, Arts and Social Sciences, 5*(6), 224-231. DOI: https://dx.doi.org/10.20469/ijhss.5.20002-6

Sharma, S. K. (2013). Risk management in construction projects using combined analytic hierarchy process and risk map framework. *IUP Journal of Operations Management, 12*(4), 23-53. Retrieved from Risk-Management-in-Construction-Projects.pdf (researchgate.net)

Shayan, S., Pyung Kim, K., & Tam, V. W. (2019). Critical success factor analysis for effective risk management at the execution stage of a construction project. *International Journal of Construction Management, 1*-8. Retrieved from https://doi.org/ 10.1080/15623599.2019.1624678

Singh, Y. K. (2006). *Fundamental of research methodology and statistics.* New Age International. Retrieved from Fundamental of Research Methodology and Statistics - Yogesh Kumar Singh - Google Books

Siraj, N. B., & Fayek, A. R. (2019). Risk identification and common risks in construction: Literature review and content analysis. *Journal of Construction Engineering and Management, 145*(9). Retrieved from https://doi.org/10.1061/(ASCE)CO.1943-7862.0001685

Sodhi, N. S., Koh, L. P., Brook, B. W., & Ng, P. K. (2004). Southeast Asian biodiversity: an impending disaster. *Trends in Ecology & Evolution, 19*(12), 654-660. Retrieved from https://doi.org/10.1016/j.tree.2004.09.006

Stephanie. (2014, December 8). *Cronbach's Alpha: Simple Definition, Use and Interpretation.* Retrieved from Calculus How To: https://www.statisticshowto.com/ cronbachs-alpha-spss/

Subramanyan, H., Sawant, P. H., & Bhatt, V. (2012). Construction project risk assessment: development of model based on investigation of opinion of construction project experts from India. *Journal of Construction Engineering and Management, 138*(3), 409-421. Retrieved from https://doi.org/10.1061/(ASCE) CO.1943-7862.0000435

Sun, Y., Fang, D., Wang, S., Dai, M., & Lv, X. (2008). Safety risk identification and assessment for Beijing Olympic venues construction. *Journal of Management in Engineering, 24*(1), 40-47. Retrieved from https://doi.org/10.1061/(ASCE)0742-597X(2008)24:1(40)

Sweet, L. (2002). Telephone interviewing: is it compatible with interpretive phenomenological research?. *Contemporary Nurse, 12*(1), 58-63. Retrieved from https://doi.org/10.5172/conu.12.1.58

Szymański, P. (2017). Risk management in construction projects. *Procedia Engineering, 208*, 174-182. Retrieved from https://doi.org/10.1016 /j.proeng. 2017.11.036

Tadayon, M., Jaafar, M., & Nasri, E. (2012). An assessment of risk identification in large construction projects in Iran. *Journal of Construction in Developing Countries, 17*, (57-69). Retrieved from Art_4_jcdc17-s1.pdf (usm.my)

Tah, J. H., & Carr, V. (2000). A proposal for construction project risk assessment using fuzzy logic. *Construction Management & Economics, 18*(4), 491-500. Retrieved from https://doi.org/10.1080/01446190050024905

Taherdoost, H. (2016). Validity and reliability of the research instrument; how to test the validation of a questionnaire/survey in a research. *How to test the*

validation of a questionnaire/survey in a research (August 10, 2016). Retrieved from http://dx.doi.org/10.2139/ssrn.3205040

Tan, W. C. K. (2002). *Practical research methods*. Prentice Hall.

Taofeeq, D. M., Adeleke, A. Q., & Hassan, A. K. (2019). Factors Affecting Contractors risk attitude from Malaysia construction industry perspective. *Social Science and Humanities Journal, 3*(6), 1281-1298. Retrieved from 402-Article_Text-843-2-10-2019061120200412-91869-etut1q-with-cover-page-v2.pdf (d1wqtxts1xzle7.cloudfront.net)

Taroun, A. (2014). Towards a better modelling and assessment of construction risk: Insights from a literature review. *International Journal of Project Management, 32*(1), 101-115. Retrieved from https://doi.org/10.1016/j.ijproman. 2013.03.004

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education, 2,* 53-55. DOI: 10.5116/ijme.4dfb.8dfd

Taylan, O., Bafail, A. O., Abdulaal, R. M., & Kabli, M. R. (2014). Construction projects selection and risk assessment by fuzzy AHP and fuzzy TOPSIS methodologies. *Applied Soft Computing, 17*, 105-116. Retrieved from https:// doi.org/10.1016/j.asoc.2014.01.003

Taylor, B. S. G., Goshal, T. (2006). *Research methodology: A guide for The Qualitative Report, 8*(4), 597-607.

Tchankova, L. (2002). Risk identification – basic stage in risk management. *Environmental Management and Health, 13*(3), 290-297. Retrieved from https://doi.org/10.1108/09566160210431088

Tembo-Silungwe, C. K., & Khatleli, N. (2017). Deciphering priority areas for improving project risk management through critical analysis of pertinent risks

in the Zambian construction industry. *Acta Structilia, 24*(2), 1-43. Retrieved from 10.18820/24150487/as24i2.1

Tepeli, E., Taillandier, F., & Breysse, D. (2021). Multidimensional modelling of complex and strategic construction projects for a more effective risk management. *International Journal of Construction Management, 21*(12), 1218-1239. Retrieved from https://doi.org/10.1080/15623599.2019.1606493

Terano, H. J. (2015). Development and acceptability of the simplified text with workbook in differential equations as an instructional material for engineering. *Asia Pacific Journal of Multidisciplinary Research, 3*(4), 89-94. Retrieved from APJMR-2015-3.4.1.1420191208-127334-7xhyqc-with-cover-page-v2.pdf (d1wqtxts1xzle7.cloudfront.net)

Thaheem, M. J., & De Marco, A. (2013). A survey on usage and diffusion of project risk management techniques and software tools in the construction industry. *World Academy of Science, Engineering and Technology, 78*, 1383-1390. Retrieved from http://hdl.handle.net/11583/2509565

Thompson, P. A., & Perry, J. G. (Eds.). (1992). Engineering construction risks: *A guide to project risk analysis and assessment implications for project clients and project managers*. London: Thomas Telford.

Thurairajah, N., Haigh, R. P., & Amaratunga, R. D. G. (2006). Leadership in construction partnering projects: *Research methodological perspective*. Retrieved from http://www.disaster-resilience.salford.ac.uk/

Tran, D. Q., & Molenaar, K. R. (2014). Impact of risk on design-build selection for highway design and construction projects. *Journal of Management in Engineering, 30*(2), 153-162. Retrieved from https://doi.org/10.1061/(ASCE)ME. 1943-5479.0000210

Trombulak, S. C., & Frissell, C. A. (2000). Review of ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology, 14*(1), 18-30. Retrieved from https://doi.org/10.1046/j.1523-1739.2000.99084.x

Tserng, H. P., Yin, S. Y., Dzeng, R. J., Wou, B., Tsai, M. D., & Chen, W. Y. (2009). A study of ontology-based risk management framework of construction projects through project life cycle. *Automation in Construction, 18*(7), 994-1008. Retrieved from https://doi.org/10.1016/j.autcon.2009.05.005

Turnbaugh, L. (2005). Risk management on large capital projects. *Journal of Professional Issues in Engineering Education and Practice, 131*(4), 275-280. Retrieved from https://doi.org/10.1061/(ASCE)1052-3928(2005)131:4(275)

Uher, T. E. (1999). Absolute indicators of sustainable construction. In *Proceedings of COBRA* (pp. 243-253).

Uher, T. E., & Toakley, A. R. (1999). Risk management in the conceptual phase of a project. *International Journal of Project Management, 17*(3), 161-169. Retrieved from https://doi.org/10.1016/S0263-7863(98)00024-6

University of Vermont, *Enterprise Risk Management Program Guide to Risk Assessment & Response*, 2012, Risk Assessment Guide. Retrieved from http://www.uvm.edu/~erm/

Violante, A., Dominguez, C., & Paiva, A. (2018). Risk Management in Construction Projects: Are Small Companies Prepared? *MOJ Civil Engineering, 4* (1), 1-7. DOI: 10.15406/mojce.2018.04. 00090

Waldron, B. (2011). Scope for improvement 2011 - Project risk getting the right balance and outcomes (27th July 2011). Retrieved from https://doi.org/10.1080/ 15623599.2016.1233087

Walliman, N. (2011). *Research Methods - The Basics*. Retrieved from https://edisciplinas. usp. br/pluginfile. php/2317618/ mod_resource/content

/1. *BLOCO% 202_Research% 20Methods% 20The% 20Basics. pdf https://www. youtube. com/watch.*

Walimuni, P. C., Samaraweera, A., & De Silva, L. (2017). Payment mechanisms for contractors for better environmental hazard controlling in road construction projects. *Built Environment Project and Asset Management, 7(*4), 426-440. Retrieved from https://doi.org/10.1108/BEPAM-11-2016-0069

Walker, D. H., & Johannes, D. S. (2003). Construction industry joint venture behaviour in Hong Kong—Designed for collaborative results?. *International Journal of Project Management, 21*(1), 39-49. Retrieved from https://doi.org/10.1016/S0263-7863(01)00064-3

Wang, M. T., & Chou, H. Y. (2003). Risk allocation and risk handling of highway projects in Taiwan. *Journal of Management in Engineering, 19*(2), 60-68. Retrieved from https://doi.org/10.1061/(ASCE)0742-597X(2003)19:2(60)

Wang, S. Q., Dulaimi, M. F., & Aguria, M. Y. (2004). Risk management framework for construction projects in developing countries. *Construction Management and Economics, 22*(3), 237-252. Retrieved from https://doi.org/10.1080/0144619032000124689

Williams, C. (2007). Research methods. *Journal of Business & Economics Research (JBER), 5*(3). Retrieved from https://doi.org/10.19030/jber.v5i3.2532

Wu, Z., Nisar, T., Kapletia, D., & Prabhakar, G. (2017). Risk factors for project success in the Chinese construction industry. *Journal of Manufacturing Technology Management, 28*(7), 850-866. Retrieved from https://doi.org/10.1108/JMTM-02-2017-0027

Yates, A., & Sashegyi, B. (2001). *Effective Risk Allocation in Major Projects: Rhetoric or Reality?: A Survey on Risk Allocation in Major WA Construction Projects. Effective Risk Allocation in Major Projects: Rhetoric or Reality*? (1-55). Barton, A.C.T.: Institution of Engineers, Australia and Chamber of Commerce and Industry of Western Australia.

Yilmaz, K. (2013). Comparison of quantitative and qualitative research traditions: Epistemological, theoretical, and methodological differences. *European Journal of Education, 48*(2), 311-325. Retrieved from https://doi.org/10.1111/ejed.12014

Yoon, Y., Tamer, Z., & Hastak, M. (2015). Protocol to enhance profitability by managing risks in construction projects. *Journal of Management in Engineering, 31*(5). Retrieved from https://doi.org/10.1061/(ASCE)ME.1943-5479.0000339

Zhang, D., Yang, S., Wang, Z., Yang, C., & Chen, Y. (2020). Assessment of ecological environment impact in highway construction activities with improved group AHP-FCE approach in China. *Environmental Monitoring and Assessment, 192*(7), 1-18. Retrieved from https://doi.org/10.1016/j.jsr.2013.05.003.

Zhang, S., Zhang, S., Gao, Y., & Ding, X. (2016). Contractual governance: Effects of risk allocation on contractors' cooperative behaviour in construction projects. *Journal of Construction Engineering and Management, 142*(6). Retrieved from https://doi.org/10.1061/(ASCE)CO.1943-7862.0001111

Zhang, Y., & Fan, Z. P. (2014). An optimization method for selecting project risk response strategies. *International Journal of Project Management, 32*(3), 412-422. Retrieved from https://doi.org/10.1016/j.ijproman.2013.06.006

Zayed, T., Amer, M., & Pan, J. (2008). Assessing risk and uncertainty inherent in Chinese highway projects using AHP. *International Journal of Project Management, 26*(4), 408-419. Retrieved from https://doi.org/10.1016/j.ijproman.2007.05.012

Zhi, H. (1995). Risk management for overseas construction projects. *International Journal of Project Management, 13*(4), 231-237. Retrieved from https://doi.org/10.1016/0263-7863(95)00015-I

Zhou, L., Vasconcelos, A., & Nunes, M. (2008). Supporting decision making in risk management through an evidence-based information systems project risk checklist. *Information Management & Computer Security, 16*(2), 166-186. Retrieved from https://doi.org/10.1108/09685220810879636

Zou, P. X., & Zhang, G. (2009). Managing risks in construction projects: life cycle and stakeholder perspectives. *International Journal of Construction Management, 9*(1), 61-77. Retrieved from https://doi.org/10.1080/15623599.2009.10773122

Zou, P. X., Zhang, G., & Wang, J. (2007). Understanding the key risks in construction projects in China. *International Journal of Project Management, 25*(6), 601-614. Retrieved from https://doi.org/10.1016/j.ijproman.2007.03.001

LIST OF BIBLIOGRAPHY

Al-Bahar J F and Crandall K C. (1990). Systematic risk management approach for construction projects, *Junior Construction Engineering Management, 116*(3), 533-546. Retrieved from https://doi.org/10.1061/(ASCE)0733-9364(1990)116:3(533)

Amaratunga, R. D. G. (2006). Construction of built and human environment. *Proceedings of the 6th international postgraduate research conference in the built and human environment.* University of Salford. Retrieved from http://usir. salford.ac.uk/id/eprint/10005

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal, 9*(2), 27-40. Retrieved from https://doi.org/10.3316/ QRJ0902027

Bryman, A. (2006). Integrating quantitative and qualitative research: how is it done?. *Qualitative Research, 6*(1), 97-113. Retrieved from https://doi.org/10.1177 /1468794106058877

Dione, S., Ruwanpura, J.Y., & Hettiarachchi, J.P.A., (2005). Assessing and managing the potential environmental risks, Practice Periodical on Structural Design and Construction @ ASCE, 260-266.

Fellows, R. F., & Liu, A. M. M. (2015). *Research Methods for Construction* (4th ed.). Chichester, West Sussex, UK: Wiley-Blackwell.

Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Methods of data collection in qualitative research: interviews and focus groups. *British Dental Journal, 204*(6), 291-295. DOI: https://doi.org/10.1038/bdj.2008.192

Hallowell, M. R., & Gambatese, J. A. (2010). Qualitative research: Application of the Delphi method to CEM research. *Journal of Construction Engineering and Management, 136*(1), 99-107. Retrieved from https://doi.org/10.1061/(ASCE)CO. 1943-7862.0000137

Hashemi, H., Mousavi, S. M., Tavakkoli-Moghaddam, R., & Gholipour, Y. (2013). Compromise ranking approach with bootstrap confidence intervals for risk assessment in port management projects. *Journal of Management in Engineering, 29*(4), 334-344. Retrieved from https://doi.org/10.1061/(ASCE)ME. 1943-5479.0000167

Kalpesh, J. (2013). Importance of Data Analysis in Research.

Kapur, R. (2018). Research methodology: Methods and strategies. Retrieved from Kapur - Research methodology Methods and strategies.pdf (ihmc.us)

Li, B., & Ren, Z. (2009, June). Bayesian technique framework for allocating demand risk between the public and private sector in PPP projects. In *2009 6th International Conference on Service Systems and Service Management* (pp. 837-841). IEEE. DOI: 10.1109/ICSSSM.2009.5174997

Maxwell, J. (2004). *Qualitative research design: an interactive approach* (2nd ed.). London: Prentice Hall Publishers.

Maxwell, J. A. (2004). Causal explanation, qualitative research, and scientific inquiry in education. *Educational Researcher, 33*(2), 3-11. Retrieved from https://doi.org/ 10.3102/0013189X033002003

Maxwell, J. A. (2012). *Qualitative research design: An interactive approach* (3rd ed.). George Mason University: SAGE Publications.

Shen, L. Y., & Tam, V. W. (2002). Implementation of environmental management in the Hong Kong construction industry. *International Journal of Project Management, 20*(7), 535-543. Retrieved from https://doi.org/10.1016/S0263-7863(01)00054-0

Smith, N. J., Merna, T., & Jobling, P. (2014). *Managing risk in construction* projects (3rd ed.). University of Leeds, London: John Wiley & Sons.

Thomas, A. V., Kalidindi, S. N., & Ganesh, L. S. (2006). Modelling and assessment of critical risks in BOT road projects. *Construction Management and*

Economics, 24(4), 407-424. Retrieved from https://doi.org/10.1080/01446190500435275

Yin, R. K. (2009). *Case study research: Design and methods* (Vol. 5). Westat: SAGE Publishers.

Zeng, J., An, M., & Smith, N. J. (2007). Application of a fuzzy based decision making methodology to construction project risk assessment. *International Journal of Project Management, 25*(6), 589-600. Retrieved from https://doi.org/10.1016 /j.ijproman.2007.02.006

APPENDICES

APENDIX A – EXPERT INTERVIEW GUIDELINE

COVERING LETTER FOR INTERVIEW GUIDELINE

K.I.L.Abhayantha,
No 45/8,
Mangala Mawatha,
Panadura.
30.04.2021

Dear Sir/ Madam,

Conducting an interview on "Management of environmental risk factors in highway construction projects in Sri Lanka with the Contractor's perspective"

I am a postgraduate student undertaking the Master Science in Project Management in Department of Building Economics, Faculty of Architecture, and University of Moratuwa. In order to complete the above programme successfully, I am conducting a research, Dissertation. The researches credentials are specified in the sections are specified in the section "Introduction to Research".

For the purpose of validate the literature findings of the study; I would like to interview you for about 45 - 75 minutes approximately, since I have recognized you as a potential source of knowledge on my research area. At the same time I would like to inform you that audio recording and note taking would be incorporated with your prior permission for accurate and reliable data collection.

Further I would like to inform you that the confidentiality of the information is strictly maintained and collected data would be employed for the above mentioned research purpose only. I kindly request your support via providing your valuable knowledge as well as opinions for the success of my research. Your support in this regard is highly appreciated.

Thanking you.

Yours sincerely,

K.I.L.Abhayantha
(Reg. No – 189586U)
abhayantha@hotmail.com

0716173002

(Dissertation Supervisor - CH. QS Prof. (Mrs.) B.A.K.S. Perera)

SECTION I - INTRODUCTION TO THE RESEARCH

Research Topic:

"Management of environmental risk factors in highway construction projects in Sri Lanka with the contractor's perspective"

Aim of the Research:

To investigate how to manage the environmental risk factors in highway construction projects in Sri Lanka with the contractor's perspective.

Objectives of the Research:

- Identify the environmental risk factors related to highway construction projects
- Evaluate the most significant environmental risk factors in highway construction projects considering contractor's perspective
- To propose the most suitable risk response strategies/ response measures to manage above identified most significant environmental risk factors
- Analyse the allocation of significant environmental risk factors
- To develop a framework to manage the environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective

SECTION II - GENERAL INFORMATION OF THE INTERVIEWEE

I. Profession:
II. Designation:
III. Organization Type:
IV. Experience in the construction industry:
V. Experience in highway construction industry:
VI. Projects which you are engaged with:

SECTION III – EXPERIENCE AND KNOWLEDGE IN CONSTRUCTION INDUSTRY

1. According to your experience and knowledge in **which stage** the **environmental risks** are **most influencing** to the Project within the **construction life cycle**? Please provide your feedback according your agreement or disagreement with each stage and if any suggestions please specify below.

Se No.	Construction life cycle	If agree mark with (√), if not mark with (X)	Any modification
1	Initiation		
2	Planning and designing		
3	Implementation and Execution		
4	Performance and monitoring		
5	Closing		

2. **Environmental risk factors** which identified via the literature review are listed below. Please identify the **environmental risk factors** which are applicable to **highway construction projects** in **Sri Lanka** considering **contractor's perspective**. Please specify "**Yes**", "**No**" or "**any modification**" according to your project experience and Knowledge. Further if you have any suggestions please specify below.

Se No.	Environmental risk factors	Yes (√)	No (X)	Any modification
1	Air and water Pollution			
2	Adverse weather conditions			
3	Introduction of chemical pollution			
4	Noise and other atmospheric effects			
5	Road related mortality			
6	Barrier effect			

Se No.	Environmental risk factors	Yes (√)	No (X)	Any modification
7	Exotic species invasions			
8	Disruption of physical environment			
9	Road edges and road effect zone			
10	Physical and biotic edge effects			
11	Ecological damage			
12	Floods, earthquakes, etc.			
13	Human invasions			
14	Modification of animal behavior			
15	Contamination of land			
16	Release to air			
17	Release to water			
18	Waste management and disposal			
19	Impact on local communities			
20	Use of raw materials and natural resources			
21	Ecological conservation			
22	Heritage conservation			
23	Emergencies			
24	Ecologically sustainable development (ESD)			
25	Difficulty to access the site (very far)			
26	Perceived Environmental Impact of Project			
27	Compliance with law and regulation for environment issue			
28	Ground conditions and contaminant			
29	Site conditions			
30	Mortality and Barriers to wildlife movement			
31	Changes to hydrology and water quality			

Se No.	Environmental risk factors	Yes (√)	No (X)	Any modification
32	Erosion and sediment transport			
33	Road as habitat corridor and conduit			
34	Landscape change and fragmentation			
35	Ecological road network theory			
36	Landslides in mountainous areas			
37	Land Pollution			
38	Dust			
39	Solid and Liquid waste			
40	Ground movements			
41	Interference with natural drainage patterns			
Any other, if				

3. Considering the previous research papers the **environmental risk can be allocated** to various contracting **parties** who engaged in the construction industry. The below table indicated **most affected parties due to environmental risks in highway construction projects**. Please specify "**Yes**", "**No**" to whom the above identified **environmental risk factors** are allocated according to your project experience and Knowledge. Further if you have any suggestions please specify below.

Se No.	Risk allocated parties	Yes (√), No (X)	Any modification
1	Client		
2	Contractor		
3	Consultant		

Se No.	Risk allocated parties	Yes (√), No (X)	Any modification
4	Supplier		
5	Sub-Contractor		
6	Contracts		
7	Designer		
8	Government agencies		
9	External		

4. Risk response is action taken to avoid risks, to reduce the occurring probability of risks, or to mitigate losses arising from risks via preparing response plans as well as select suitable measures to handle the risks. Accordingly it is required to select **suitable measures** for the above risk response strategies after identify, classify, analyze, assess and allocate the **environmental risk factors** from the contracting parties. The below table indicated the identified **risk response strategies**. Please specify "**Yes**", "**No**" or "**Any modification**" according to your project experience and Knowledge. Further if you have any suggestions please specify below.

Se No.	Risk response strategies	Risk response measures	Yes (√)	No (X)	Any modification
1	Risk Transfer	Transferred risk via contract documents from main contractor to subcontractor			
		The contractors can transfer the financial losses occurred due to all risk events through insurance companies			
		Claiming cost of damages			
		Employer can transfer obligations to contractor via selecting the path as design and built by contractor			
		Transfer the risk management responsibilities to third parties (consultant)			
		Transfer the risks to other parties via contractual shifting (Performance encouragement, insurance, warranties, bonds, etc.)			
		Assign uncertain tasks under contractor's scope			
	Any other risk measures				
2	Risk Avoidance	Contractor can go for high bid price for tendering as well as specified required conditions in the bid			
		If the current construction activities are affected then contractor can go for an alternative construction method to keep the construction schedule alive			
		Countries are financially and politically unstable then avoid bidding for the above construction projects			
		To avoid unreasonable claims inspect the houses and buildings for cracks before commence the construction			
		If the records are having doubts or issues continuously keep the crack inspection records			
		Changed the plans as well as designs to avoid risks			
	Any other risk measures				

Se No	Risk response strategies	Risk response measures	Yes (√)	No (X)	Any modification
3	Risk Acceptance (Risk retention)	Doing nothing and accepted any of result			
		Develop an emergency plan in case any risk event has been occurred			
		Accept lower profit for any affected event			
		Employment of specialist from outside in case in house skills not available			
		Sub-Contracting of works/ Keep own machinery and plant for works			
		Minimize unnecessary delays in decision making			
		Accept all the results arising due to risks and keeping a contingency plan			
	Any other risk measures				
4	Risk Mitigation (Risk reduction)	Jointly work to obtain approvals for the works			
		Cooperation with other contractual parties such as employer, contractor, sub-contractor, engineer (team work)			
		Carried out education and training secessions to the employees of the organization			
		Control risk magnitude by reducing any of risk components which severely affected the project			
	Any other risk measures				

APENDIX B – Questionnaire Survey Round 1

K.I.L.Abhayantha,
No 45/8,
Mangala Mawatha,
Panadura.
19.07.2021

Dear Sir/ Madam,

Conducting an questionnaire survey on "Management of environmental risk factors in highway construction projects in Sri Lanka with the Contractor's perspective"

I am a postgraduate student undertaking the Master of Science in Project Management in Department of Building Economics, Faculty of Architecture, and University of Moratuwa. In order to complete the above programme successfully, I am conducting a research, Dissertation.

For the purpose of validate the interview findings of the study; herewith attached a questionnaire survey, since I have recognized you as a potential source of knowledge on my research area.

Further I would like to inform you that the confidentiality of the information is strictly maintained and collected data would be employed for the above mentioned research purpose only. I kindly request your support via providing your valuable knowledge as well as opinions for the success of my research. Your support in this regard is highly appreciated.

Thanking you.

Yours sincerely,

K.I.L.Abhayantha
(Reg. No – 189586U)
abhayantha@hotmail.com
0716173002

(Dissertation Supervisor - CH. QS Prof. (Mrs.) B.A.K.S. Perera)

SECTION I - INTRODUCTION TO THE RESEARCH

Research Topic:

"Management of environmental risk factors in highway construction projects in Sri Lanka with the contractor's perspective"

Aim of the Research:

To investigate how to manage the environmental risk factors in highway construction projects in Sri Lanka with the contractor's perspective.

Objectives of the Research:

- Identify the environmental risk factors related to highway construction projects
- Evaluate the most significant environmental risk factors in highway construction projects considering contractor's perspective
- To propose the most suitable risk response strategies/ response measures to manage above identified most significant environmental risk factors
- Analyse the allocation of significant environmental risk factors
- To develop a framework to manage the environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective

SECTION II - GENERAL INFORMATION OF THE INTERVIEWEE

Please fill you details in first three cages and highlight with preferred color according to your experience in the industry.

Designation	
Profession	
Organization Type	
Total Experience in Construction Industry	☐1-5 ☐5-10 ☐10-15 ☐15-20 ☐20-25 ☐more than 25
Experience in Highway Construction Projects	☐1-5 ☐5-10 ☐10-15 ☐15-20 ☐20-25 ☐more than 25

SECTION III – EXPERIENCE AND KNOWLEDGE IN CONSTRUCTION INDUSTRY

1. Rank the **frequency level of risk occurrence** and **Impact (significance) of environmental risk factors** due to construction of **highway projects** in Sri Lanka considering **contractor's perspective** via "**Highlighting**" the suitable value with preferred colour**.**

   Please use the suitable ranking as preferred according to the scales given below

   1 – Very Low
   2 – Low
   3 – Medium
   4 – High
   5 – Very High

   General Example: Think about occurrence of Tsunami. Tsunami occurs very rarely, hence **frequency level** is "**Very Low**". Accordingly we can select **frequency scale** as ① and highlighted.
   But **impact (significance)** of tsunami is "**Very High**". Accordingly we can select Impact (Significance) scale as ⑤ and highlighted.

No	Environmental risk Factor	Frequency level of risk occurrence					Impact (Significance) of risk factors				
1	Air and water Pollution	①	②	③	④	⑤	①	②	③	④	⑤
2	Adverse weather conditions	①	②	③	④	⑤	①	②	③	④	⑤
3	Introduction of chemical pollution	①	②	③	④	⑤	①	②	③	④	⑤
4	Noise and vibration	①	②	③	④	⑤	①	②	③	④	⑤
5	Mortality and Barriers effect to wildlife movement	①	②	③	④	⑤	①	②	③	④	⑤
6	Exotic species invasions	①	②	③	④	⑤	①	②	③	④	⑤
7	Disruption of physical environment	①	②	③	④	⑤	①	②	③	④	⑤
8	Ecological damage	①	②	③	④	⑤	①	②	③	④	⑤
9	Floods	①	②	③	④	⑤	①	②	③	④	⑤
10	Human invasions	①	②	③	④	⑤	①	②	③	④	⑤
11	Modification of animal behavior	①	②	③	④	⑤	①	②	③	④	⑤
12	Contamination of land	①	②	③	④	⑤	①	②	③	④	⑤
13	Improper construction and solid waste disposal	①	②	③	④	⑤	①	②	③	④	⑤
14	Impact on local communities	①	②	③	④	⑤	①	②	③	④	⑤

No	Environmental risk Factor	Frequency level of risk occurrence					Impact (Significance) of risk factors				
15	Natural resources depletion in Sri Lanka like soil, sand, aggregate etc.	①	②	③	④	⑤	①	②	③	④	⑤
16	Not according to Ecologically sustainable development (ESD)	①	②	③	④	⑤	①	②	③	④	⑤
17	Difficulty to access the site due to most sensitive areas	①	②	③	④	⑤	①	②	③	④	⑤
18	Perceived Environmental impact of Project	①	②	③	④	⑤	①	②	③	④	⑤
19	Non - Compliance with law and regulation for environment issue	①	②	③	④	⑤	①	②	③	④	⑤
20	Poor site conditions which not complied with EMP	①	②	③	④	⑤	①	②	③	④	⑤
21	Road as habitat corridor	①	②	③	④	⑤	①	②	③	④	⑤
22	Landscape change and fragmentation	①	②	③	④	⑤	①	②	③	④	⑤
23	Landslides in mountainous areas	①	②	③	④	⑤	①	②	③	④	⑤
24	Impacts on the natural drainage patterns and issues of irrigation water	①	②	③	④	⑤	①	②	③	④	⑤
25	Loss of endangered and endemic flora and fauna species found in project areas	①	②	③	④	⑤	①	②	③	④	⑤
26	Public complaints and obstruction to the work from nearby residents	①	②	③	④	⑤	①	②	③	④	⑤
27	Crop damage due to erosion	①	②	③	④	⑤	①	②	③	④	⑤
28	Ground water depletion due to large excavation, cuts and tunnels	①	②	③	④	⑤	①	②	③	④	⑤
29	Light and sound pollution where the road cross in sanctuaries	①	②	③	④	⑤	①	②	③	④	⑤
30	Shade effect due to via duct or large bridges	①	②	③	④	⑤	①	②	③	④	⑤
31	Loss of vegetation	①	②	③	④	⑤	①	②	③	④	⑤
32	Loss of breading site	①	②	③	④	⑤	①	②	③	④	⑤
33	Changes in cropping pattern and yield loss	①	②	③	④	⑤	①	②	③	④	⑤
34	Loss of bio diversity	①	②	③	④	⑤	①	②	③	④	⑤
35	Degradation of land due to material extraction	①	②	③	④	⑤	①	②	③	④	⑤
36	Disturbances and fragmentation of natural habitats	①	②	③	④	⑤	①	②	③	④	⑤
37	Disturbances for migration routes of animals	①	②	③	④	⑤	①	②	③	④	⑤

APENDIX C – Questionnaire Survey Round 2

K.I.L.Abhayantha,
No 45/8,
Mangala Mawatha,
Panadura.
04.11.2021

Dear Sir/ Madam,

Conducting an questionnaire survey on "Management of environmental risk factors in highway construction projects in Sri Lanka with the Contractor's perspective"

I am a postgraduate student undertaking the Master of Science in Project Management in Department of Building Economics, Faculty of Architecture, and University of Moratuwa. In order to complete the above programme successfully, I am conducting a research, Dissertation. The researches credentials are specified in the sections are specified in the section "Introduction to Research".

For the purpose of validate the interview findings of the study; herewith attached a questionnaire survey, since I have recognized you as a potential source of knowledge on my research area.

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Research Topic:

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- Evaluate the most significant environmental risk factors in highway construction projects considering contractor's perspective
- To propose the most suitable risk response strategies/ response measures to manage above identified most significant environmental risk factors
- Analyse the allocation of significant environmental risk factors
- To develop a framework to manage the environmental risk factors in highway construction projects in Sri Lanka with contractor's perspective

SECTION II - GENERAL INFORMATION OF THE INTERVIEWEE

Please fill you details in first three cages and highlight with preferred color according to your experience in the industry.

Designation	
Profession	
Organization Type	
Total Experience in Construction Industry	☐1-5 ☐5-10 ☐10-15 ☐15-20 ☐20-25 ☐more than 25
Experience in Highway Construction Projects	☐1-5 ☐5-10 ☐10-15 ☐15-20 ☐20-25 ☐more than 25

SECTION III – EXPERIENCE AND KNOWLEDGE IN CONSTRUCTION INDUSTRY

2. Please rank the most reasonable – Risk Response Measures according to your preference with suitable codes considering the Environmental Risk Factors specified at end of this question.

1 – Very Low significant
2 – Low significant
3 – Medium significant
4 – High significant
5 – Very High significant

Code	Risk Response Measures	Code	Risk Response Measures
RTR 1	Transfer the risks at blasting, tunnel excavation including environmental rehabilitation via contract documents	**RAC 3**	Minimize unnecessary delays in decision making
RTR 2	Contractor can transfer the losses caused by environmental risk occurrences through insurances companies	**RAC 4**	Perform earthworks at nearby water bodies in dry periods
RTR 3	Transfer obligations to contractor via selecting the path as design and built by contractor	**RAC 5**	Keep opening sizes of the bridges and culverts in large to free pass the flood flow
RTR 4	Transfer the risk to other parties via contractual shifting other than insurances warranties and bonds	**RAC 6**	Introduce crop diversification plan or provide temporary jobs for the victim farmers
RTR 5	Assign all the environmental obligations under contractor's scope	**RAC 7**	Introducing new forest reservations to compensate the damages to the environment due to project activities
RTR 6	Damages to the cultivated areas to be claimed by client	**RMI 1**	All construction parties can jointly work as a team
RAV 1	If the current construction activities are affected by unexpected conditions, then go for alternative construction methods	**RMI 2**	Demonstrate about the worker behavior pattern at construction at environmental conserved areas
RAV 2	Done the pre crack survey before the commencement of construction works.	**RMI 3**	Involve with joint inspections, monitoring mechanisms with Government Regulatory Bodies such as RDA, GSMB, NBRO
RAV 3	Update the crack survey and maintain the records	**RMI 4**	Mitigate improper drainage and water logging by introducing new designs such as collector drains
RAV 4	Change the designs with the help of Environmental specialist for avoiding environmental risks	**RMI 5**	Control the velocity of the flood flow with suitable barriers
RAV 5	Request the environmental clearance certifications from the employer before mobilizing to the site	**RMI 6**	Provide bio links, animal overpass, canopy bridges, eco duct and under passes designs
RAV 6	Maintain the continuity of irrigation and drainage canals/ paths within construction sites	**RMI 7**	Strictly adhere to environmental management plan
RAV 7	Dump disposals in an approved locations to avoid contact with terrestrial and aquatic habitats	**RMI 8**	Well maintain the natural drainage network in order to movement of the aquatic species
RAV 8	Erect sign boards at the places where animals are likely to be entered	**RMI 9**	Erect meshed fences to avoid entrance of animals to highways
RAV	Make EIA report approval process very	**RMI**	Educate project stake holders with reduce ,

Code	Risk Response Measures	Code	Risk Response Measures
9	strict by Government authorities	10	reuse and recycle circular built environment principles in highway constructions
RAC 1	Develop an emergency plan and risk assessment matrix to identify severity and likelihood for expected risk factors	RMI 11	Introduce a point system to encourage the use of recycle material
RAC 2	Employment of external specialist in case in house skills not available	RMI 12	Design the highways by considering environmental effects more than the cost effectiveness

Select the suitable ranking as preferred according to the scales given above. Please go through the example before answer.

No	Most significant Environmental Risk Factors	Risk Handling Techniques / Risk Response Measures				
		1	2	3	4	5
	Example : Natural resources depletion in Sri Lanka like soil, sand, aggregate etc.	RMI 7	RAV 10	RMI 12	RMI 10	RMI 11
1	Natural resources depletion in Sri Lanka like soil, sand, aggregate etc.					
2	Landscape change and fragmentation					
3	Disturbances for migration routes of animals					
4	Floods					
5	Loss of bio diversity					
6	Landslides in mountainous areas					
7	Disruption of physical environment					
8	Loss of vegetation					
9	Impacts on the natural drainage patterns and issues of irrigation water					
10	Improper construction and solid waste disposal					
11	Noise and vibration					

3. According to your experience percentage (%) wise indicate to whom the Environmental risks can be allocated in highway construction projects in Sri Lanka? (The total must be 100% at the end)

No	Environmental Risk Factors	Risk Allocation to the Contracting parties (Total must be 100% at the end)		
		Client	Contractor	Consultant

No	Environmental Risk Factors	Risk Allocation to the Contracting parties (Total must be 100% at the end)		
		Client	**Contractor**	**Consultant**
	Example : Environmental Risk XXX	30%	65%	5%
1	Natural resources depletion in Sri Lanka like soil, sand, aggregate etc.			
2	Landscape change and fragmentation			
3	Disturbances for migration routes of animals			
4	Floods			
5	Loss of bio diversity			
6	Landslides in mountainous areas			
7	Disruption of physical environment			
8	Loss of vegetation			
9	Impacts on the natural drainage patterns and issues of irrigation water			
10	Improper construction and solid waste disposal			
11	Noise and vibration			