

Risk identification for bridge construction projects - A case study in the Mekong delta Region under climate change

Xác định các nhân tố rủi ro cho dự án xây dựng cầu - Trường hợp điển hình tại ĐBSCL dưới tác động biến đổi khí hậu

> DR NGUYEN VAN TIEP^{1,*}; MSC NGUYEN MINH DUC²

¹International University, Vietnam National University, Ho Chi Minh City

²Ho Chi Minh City University of Transport; *Email: nvtiep@hcmiu.edu.vn

ABSTRACT

Many studies have attempted to identify the critical risk of construction projects; but only a few studies focus on synthesizing risk identification techniques of construction projects, particularly in bridge construction projects with the consideration of the climate change. Thus this paper aims to synthesize risk factors of construction projects through a literature review from 2000 to 2023; and then examines practical documents from bridge projects to provide comparisons and highlight the characteristics of climate change that may influence bridge project performance. The initial findings show that eight risk assessment methods; forty common risk factors of construction projects; and seven critical risk factors caused by climate change in which should be assessed at the initial stage of bridge projects. The benefit of this paper is to support decision-makers to have a full understanding about risk management techniques, particularly when examining the impact of climate change and associated risks on bridge project implementation in practice.

Keywords: Risk Identification; risk management; bridge projects; climate change.

1. INTRODUCTION

Risk management in construction is of great importance during the whole project life cycle [1]. Risk management refers to the practice of identifying potential risks in advance, analyzing them and taking precautionary steps to reduce the risk [2]. The objective of risk management is to find and manage risks in order to complete the project successfully. Risk is often known as uncertain events and they do have an influence on construction projects. The Project Management Institute (PMI) argued that risk is: "an uncertain event or condition that, if it occurs, has a positive or

negative effect on a project's objectives". However, many studies have a certain that risks are unexpected events that are considered on as a loss [3],[4]. Risks impact on bridge projects in terms of time, cost, quality and its outcomes [5].

Risk identification plays an important role in risk management, and risks cannot be assessed when they are not recognized. A large number of studies have been carried out in different construction projects and different areas to establish relevant risks. Therefore, it is necessary to have a review to synthesize risk factors from previous publications and point out what methods have been applied in risk identification efforts. Through a literature review, this study provides a list of risks in construction projects. Construction activities are closely related to environmental and geographic characteristics. In this article, in addition to literature review survey in previous findings, this paper presents a case study of bridge projects in the Mekong delta region, where climate change has had many impact.

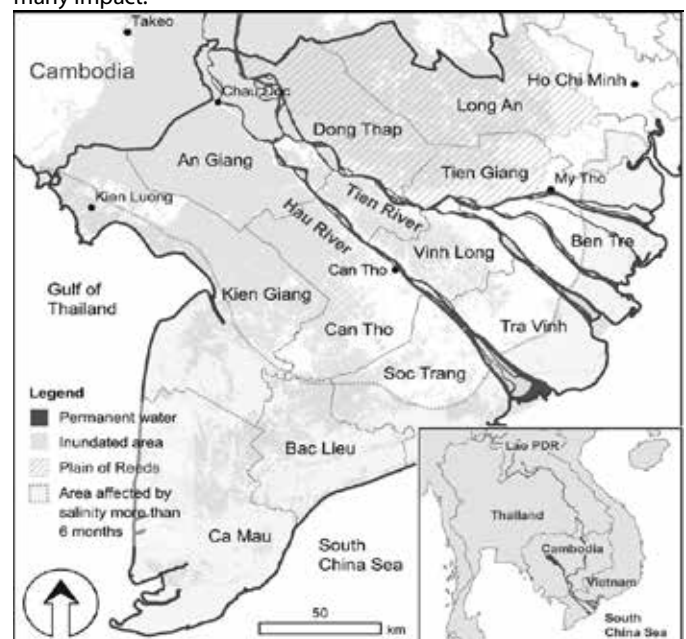


Figure 1. Mekong Delta region, Vietnam [8]

The delta area is located in the southwest region of Vietnam, between 8.5°–11.5° N and 104.5°–106.8°E, covering an area of around 40,000 km². The humid tropical monsoon climate in this Mekong delta region is associated with an annual average temperature of 27 °C and average annual rainfall of 1800 mm. However, there are variations across this area because of differences in the climate regime, especially in terms of temperature and humidity [6]. This region is assessed as one of the most vulnerable mega-deltas, and being subjected to climate change brings the threat of sea level rise as well as changes to local climates including higher temperatures, altered water balance, and extreme events such as droughts and floods [7]. Bridge projects built in the Mekong delta region might suffer potential risks caused by climate change. However, there are very few studies that have clarified climate change-related hazards. Therefore, a survey was carried out by our research team in this area in order to better present these risk factors. In addition, the result of the survey will be used to compare risk data from previous publications.

2. RESEARCH METHOD

The first step in the risk management process is risk identification [9]. Risks that are not recognized also cannot be analyzed and responded to. Therefore, the first task of risk management is to cover the potential risks as completely as possible. The method of literature review is applied to summarize research works carried out in risk identification for construction projects. A systematic search of Google Scholar from the year 2000 to 2023 was implemented using a combination of keywords to search for relevant articles as follows: Construction projects; Bridge projects; Construction Risk management; Risk identification; Risk

Table 1. Risks in bridge construction

Risk Code	Risks	Literature review (References)	Survey on Mekong Delta region
R1	Environmental risk	[10], [11], [12], [13], [14], [15], [16]	x
R2	Political	[10], [17], [18], [19], [20], [11], [21], [22], [15]	x
R3	Social and economic risk	[18], [12], [17], [23], [22], [15], [24]	x
R4	Contractual agreement risk	[1], [13], [14], [25], [15], [26]	x
R5	Financial risk	[11], [17], [21], [27], [22], [25], [15], [26]	x
R6	Construction risk	[12], [18],[22]	x
R7	Project risk	[10], [12], [18]–[21], [27]–[29], [14]	x
R8	Market risk	[1], [14], [5]	
R9	Safety risk	[10], [25]	x
R10	Quality risk	[1], [10], [20], [28]	x
R11	Personal risk	[17]	
R12	Cost risk	[1], [18], [29], [14]	x
R13	Deadline risk	[1], [14], [25]	
R14	Strategic decision risk	[1]	
R15	External risk	[1], [27]	x
R16	Operational risk	[17], [27]	x
R17	Legal risk	[17], [21], [29], [22], [30], [31]	x
R18	Currency and inflation	[17], [28]	
R19	Corruption risk	[17], [30]	

assessment. After searching, our research team established a list of 192 related articles. Based on our selection criteria which focuses on the confidence level of risk identification, a short list of 52 results emerged. In the following step, our research team read carefully the titles and abstracts and skimmed the whole study. Finally, 28 of 52 publications were selected to present the potential risk factors in bridge projects.

The study area is Mekong delta region in Vietnam which is considered to be experiencing a large impact caused by climate change. Bridge projects built in the Mekong delta region are facing a number of featured risks that might not occur in other regions: and these risks have serious effects on the efficient completion of the entire project. Although there have been numerous studies performed related to risk management, no research has clarified risk factors caused by climate change. By carefully studying documentation regarding bridge projects built in the Mekong delta region, Vietnam, this study has identified the risks and focused on hazards regarding climate change. We conducted this method by collecting information from 30 bridge projects between the year 2000 and 2020 in Mekong delta region which are under construction or operation. The results of the survey were used to compare with previous studies and clarify risks caused by climate change.

3. FINDINGS

By aggregating the results from the literature review method and the survey of bridge projects carried out in the Mekong delta region in the period of 2010 - 2021, a table of potential risks was established as below (The risks appearing through survey on Mekong delta region is marked by letter "x"):

Risk Code	Risks	Literature review (References)	Survey on Mekong Delta region
R20	Tendering procedures	[17], [13], [26]	
R21	Supplier risk	[18], [30], [31]	x
R22	Technical risk	[11], [18], [13], [22], [14], [15], [32], [24], [5]	x
R23	Resources risk	[12], [18], [28]	x
R24	Information risk	[18], [29], [22], [14], [31]	
R25	Inexperience of project members	[28], [30], [5]	x
R26	Lack of motivational approach	[18], [28], [29], [24]	
R27	Efficiency risk	[18], [30]	
R28	Payment security risk	[20], [23], [33]	
R29	Programme overrun risk	[23], [30]	
R30	Subcontractor pricing risk	[23], [13], [25]	
R31	Management risk	[12], [21], [27], [13], [15], [26], [32], [24]	x
R32	Labour risk	[19], [20], [14]	x
R33	Time risk	[19], [13], [14], [25]	
R34	Budget risk	[19], [14], [16], [31]	
R35	Contractor risk	[21], [13], [25]	
R36	Natural diaster risk	[20], [21], [16]	x
R37	Equipment risk	[21], [13], [14], [24]	
R38	Funding risk	[20], [25], [33]	
R39	Exchange rate fluctuation risk	[20], [25]	
R40	Site condition	[20],[22], [14], [25], [26]	x

The result shows that 40 risks have been recognized by previous studies. Financial risk, project risk, legal risk, technical risk, information risk, management risk and site risk are identified in many studies. When compared with bridge projects in Mekong delta region, 21 of these 40 risks have occurred. Besides surveying on risks in general, this study focused on the risk factors originating from climate change as a part of environmental risks. Previous studies described “Environmental risk” as having the following characteristics [15]:

- Adverse weather conditions
- Case of force majeure
- Unfavorable environmental impacts of the project
- Pollution associated with construction activities

- Strict environmental regulations and requirements
- Poor environmental regulations and management
- Changes in environmental standards and permissions
- Poor preliminary assessment and evaluation of the environmental impacts of the project
- Prosecution due to unlawful disposal of construction waste
- Failure to obtain environmental approval

The descriptions listed by prior researchers do not completely clarify the impact of environmental risk on bridge projects in this area which is seriously influenced by climate change. Review of 30 bridge project documents located in Mekong delta region revealed the top 7 risk factors generated by climate change, as below:

Table 2. Climate change-relate risks in bridge projects in mekong delta region

No	Risk factors	Project phase		The number of projects	Percentage
		Construction	Operation		
1	Rise in sea level		x	28	93.33
2	Erosion	x	x	27	90.00
3	Heavy rain	x	x	25	83.33
4	Temperature		x	16	53.33
5	Saltwater intrusion	x	x	15	50.00
6	Storm		x	9	30.00
7	Flooding	x	x	8	26.67

• Sea level rising, erosion and heavy rain are risk factors appearing in most of the projects surveyed, accounting for more than 83.33% of total number of projects in the Melong. Rise in sea level is caused by the melting ice in two hemispheres, resulting in increasing water levels in the local rivers. This is also responsible for saltwater intrusion in the Mekong delta region. A number of old bridges are no longer operated efficiently because of the changes in bridge's clearance. Heavy rain makes it difficult for construction progress, leading to delays in project schedule and cost-overflow.

• Temperature and saltwater intrusion often occur in the bridge projects surveyed at the rate of 53.33% and 50.00% respectively. High temperature and temperature variation affects the quality and working condition of building materials. Saltwater intrusion changes the chemical composition of water, causing corrosion in bridge structures.

• Storm and flooding are considered to be natural disasters, affecting around 30% projects in the Mekong delta region. These risk factors seriously have a serious impact on bridge projects. However, these factors have a very low frequency of occurrence.

While all of climate change-related risk factors appeared in operation phase, construction phase has to face with *Heavy rain, Saltwater intrusion* and *Flooding*.

4. CONCLUSION

The impact of climate changes on construction projects is becoming serious and is starting to receive attention from both scholars and the public. This study has attempted to identify critical risk factors of construction projects and associated risk assessment methods. In particular the paper focuses on the impact of climate change to investigate potential risk caused, in which there are impacts on the bridge project performance. In the scope of the study, the Mekong delta region was selected as a typical case study since this region is one of the regions that is significantly affected by climate change, as reported by the IPCC [34]. Through a review of the project documents from 30 bridge projects, we found out that 07 critical risk factors caused by climate change are as follows: rise in sea level, erosion, heavy rain, high temperature, saltwater intrusion, storm, and flooding. Such risk factors should be carefully examined at the initial stage of a bridge project to ensure the feasibility of project implementation and operation.

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