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A total environmental risk assessment model for international hub airports

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Abstract

This paper presents a multi-criteria decision analysis for environmental risk assessment (ERA) with regard to avoiding and eliminating damages and loss under natural disasters in international airport projects. It starts from an assumption that the strategy of eliminating damages and losses under natural disasters is related to the location selection problem, and it is necessary to use the multi-criteria decision analysis for calculated decision-making support. The paper uses the analytic network process (ANP) to demonstrate one of its utility modes in decision-making support to location selection problems, which aims at an evaluation of different projects from different locations. A set of generic criteria for risk assessment at international projects was put forward to support ANP modelling, and it was due to the consideration of social, technical, economic, environmental and political (STEEP) criteria related to the built, social and natural (BSN) trinity environment of international airport projects. At the end, an experimental case study on three international hub airports in China is given to test the ANP model called ERA.Airport, and it is concluded that ANP can be effectively used for risk assessment in the specific utility mode. The ERA.Airport is a generic multi-criteria decision-making model and can be used across the world for accurate environmental risk assessment for international airports.

Keywords: Environmental risks; Risk assessment; Location selection; Urban clusters; Airport; China

1. Introduction

Environmental risks are risks to the natural health and productivity of environmental systems and risks to human health stemming from alteration and/or degradation of environmental systems (Böhm et al. 2001; Lerche and Glaesser, 2006), and these risks are therefore related to both extreme natural phenomena (natural disasters such as earthquake, tsunami, storms, flood, landslide, avalanche, blizzard, hail, etc.) and the socioeconomic consequences and the repercussions of those natural disasters in terms of economic growth and social progress at local, regional or international scale, in addition to all identified hazards and damages to either natural or human health due to pollution generated from facilities such as buildings and civil infrastructures through lifecycles.

For construction and development projects, the environmental impact assessment (EIA), as a useful environmental risk assessment (ERA) tool, has been widely used across the world to evaluate adverse environmental impacts. However, the opposite impacts of natural disasters to the built environment, especially those mega projects, concerning significant damages have not been fully studied although lessons have been learnt from consequences of various natural disasters internationally, and a total ERA to reflect interactive impacts and interactions among the built environment, the social environment, and the natural environment, which are called the built, social, and natural (BSN) trinity environment in this paper, is assumed an advanced rather than a conventional EIA. Therefore the shift from EIA to ERA enables a comprehensive assessment with more proactive approaches, instead of reactive measures focused only on protecting the natural environment, or

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evaluating risks of potential damage and/or loss inside the BSN trinity environment as a whole or separately. It is still a vital challenge to effectively avoid damages due to natural disasters to mega projects in response to various needs inside the BSN trinity environment.

It is the purpose of this paper is to introduce a new ERA approach to evaluate the level of environmental risks, which can lead to significant interactive impacts, huge damages and long-term influences inside the BSN trinity environment, for one new project or among different existing projects at different locations; and the proposed approach aims at calculated decision-making support for eliminating or reducing the opposite impacts of natural disasters in mega project construction and development. With regard to the application of the ERA approach, this paper aims at a practical methodology. Based on an assumed strategy of the construction and development of mega projects to avoid environmental risks and damages due to environmental alternations, it is an ideal situation to choose an appropriate location for a specific project, which has been widely recognised in feasibility study, and the problem of location choice is therefore targeted as a specific application of ERA. Since the BSN trinity environment is supposed for the ERA, risks associated to a complete assessment consist of risks from not only the natural environment but also the social and the built environments. The paper further describes the entire methodology of ERA by using analytic network process (ANP) (Saaty, 1996) through a case study on three international hub airports in China.

2. Location choice against environmental risks

2.1. The problem

The choice of facilities location is an important decision made by clients at the feasibility study stage of new construction projects. For example, the CIOB (2010) has defined location as one of the four client's objectives in apposition with budget, time and function in project feasibility studies. For mega projects, location problem has already been identified by Flyvbjerg et al. (2003), based on their studies into several hundred mega projects in twenty nations across five continents over decades, as one influential factor concerning its impacts to the project and associated risks, and a lot of operational evidences recently collected from projects show exactly the consequences of adverse socioeconomic impacts that natural disasters can make. For instance, five Eurostar trains failed in the Channel Tunnel during the night from 18th to 19th December 2009 due to snowstorm, and Eurostar services were suspended for 3 days, causing severe disruption to thousands of passengers; and the ban on flights due to the volcanic ash cloud from the Iceland volcano eruption in April 2010 costs the UK airports operator BAA between £5 million and £6 million a day (BBC, 20 April 2010) in airport operation; in addition, the havoc of summer floods is also recognised as operational risk for mega projects (Allport and Ward, 2010). These cases not only indicated the risks posed by the potential impacts from natural disasters and the natural environment, but also showed the urgent needs for readiness and resilience for mega projects against natural disasters and environmental degradation; moreover, it is also implicated that the choice of location for mega projects is so important to avoid adverse impacts due to possible natural disasters. It is therefore a research and practical question regarding how to choose an appropriate location for any proposed mega project to avoid or eliminate the risks due to natural disasters, and little effort has been made to tackle it in relation to the existing principles and methods of locating facilities.

2.2. Approaches

Risk assessment has been defined by the BSI (2010) as an overall process of risk identification, analysis and evaluation; in regard to this definition, 31 risk assessment techniques are given for organisations to use and those techniques have been classified accordingly into three categories for risk identification, risk analysis, and risk evaluation. Nine of those techniques are further identified strongly applicable for risk evaluation in terms of determining the level of risk, and a comparison of their applicability in ERA against natural disaster risks for mega projects is given in Table 1.

In this comparison, the process of an ERA against natural disaster risks is defined to cover four inter-connected stages, including the description of the risk environment and situation, the evaluation of consequences in regard to separated risk impacts and interactions, the optimisation of proposed project plans to avoid and eliminate risks, and the prediction of positional risks and their consequences under different natural disaster scenarios. According to this comparison, the multi-criteria decision analysis technique is identified as the most appropriate one to undertake ERA against natural disaster risks.

In terms of the problem of location choice, it has been noticed through literature review that quantitative approaches, especially the multi-criteria decision analysis technique (Figueira et al., 2005; Karkazis, 1989; Schilling, 1980), have been either

Table 1
Applicability[a] of risk assessment techniques for ERA against natural disaster risks.

Risk assessment t echniques	Functions to support ERA			
	Description	Evaluation	Optimization	Prediction
Bow tie analysis	Medium	Medium	Weak	Weak
Consequence/probability matrix	Medium	Medium	Weak	Weak
Failure mode effect analysis	Weak	Weak	Weak	Weak
Human reliability analysis	Weak	Weak	Weak	Weak
Multi-criteria decision analysis	Strong	Strong	Medium	Weak
Reliability centred maintenance	Weak	Weak	Weak	Weak
Root cause analysis	Weak	Weak	Weak	Weak
Structured "what-if" technique	Medium	Weak	Weak	Weak
Toxicity assessment	Weak	Weak	Weak	Weak

[a] BSI (2010).