Chapter 16
Managing Construction Development Risks to the Environment

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Abstract The control of environmental risks arising from construction has become a major issue for the public. Environmental risk is defined as any risk or potential risk to the environment (of whatever degree or duration) and includes all types of impacts. Much of the research conducted has portrayed construction as a major contributor to environmental disruption and pollution. Pollution risks due to construction are typically classified as air pollution, waste pollution, noise pollution, and water pollution. Controlling the risks demands the ability to manage these types of pollution or eliminate their generation. The endorsement of environmental risk management and the mission of sustainable development have resulted in pressure demanding the adoption of proper methods to improve environmental performance in the construction industry. This chapter therefore places its focus on the risks arising from the construction industry, and how to manage these risks so as to strike a balance between development and environmental concerns. Real examples of construction activities are briefly presented to enable readers to envision the risks and the actual efforts undertaken to curb them. This chapter also presents the perception of the public at large regarding the risks caused by construction.

Keywords Construction-related pollution • Environmental risks of construction • Sustainable construction

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16.1 Introduction

Construction is not an inherently environmentally friendly industry and much research has linked it to environmental disruption and pollution. Construction is one of the major contributors to environmental impacts carrying pollution risks, typically classified as air pollution, waste pollution, noise pollution, and water pollution. Activities in construction are complex, highly dispersed, and resource-demanding. The industry contributes to the loss of important natural assets and imposes severe impacts and stress on the environment. Construction activities and practices that fail to control risks to the environment can cause damage to rivers, lakes, sensitive ecosystems, and aquatic life, including causing fish kills. They can also disrupt wildlife habitats and result in contamination of land and groundwater (Sanvicens and Baldwin 1996). The risks to the environment are particularly high when work is undertaken on highlands, steep slopes, and near coastal areas, rivers, and lakes.

In Malaysia, the construction industry has yet to achieve full sustainability, and the environment is frequently being irretrievably altered, while risks are poorly handled. A marked example is in Penang by the tendency to re-designate optimum locations or sensitive zones such as fish landing grounds for upscale developments. In light of the potential consequences, site selection needs to be undertaken with greater thoroughness and deliberation, including efforts should be made to save energy via construction of green buildings. Green buildings are specially designed to cause less risk to human health and the environment through efficient use of energy, water, and other resources, with a concurrent reduction in waste, pollution and environmental impacts.

According to Tam et al. (2004), sustainable construction requires the local construction industry to be viable, capable, and alert to the imperatives of sustainable construction in all its activities. Input from those who can make changes in the industry, such as developers, contractors, architects, planners, and others must be provided in a cohesive and willing manner (Gangolells et al. 2011; Christini et al. 2004).

16.2 Environmental Risks of Construction

16.2.1 Risk of Land Degradation

Large projects usually entail extensive land disturbance involving the removal of vegetation and reshaping of topography. Such activities make the soil vulnerable to erosion. Soil removed by erosion may become airborne and create dust problem or be carried by water into natural waterways, thereby polluting them. Due to the soil erosion of the exposed and loose earth, there will be a deterioration of water quality in the surrounding water bodies due to siltation. This can result in mud floods and flash floods in immediate or downstream areas during heavy downpours. Landslides and slope failure can occur on unstable slopes or when the soil is saturated with water during heavy rainfalls.

16.2.2 Risk to Flora and Fauna

The biological environment includes various species of animal and plant life, and their habitats. Unfortunately, however, loss of flora and fauna is likely in any development. Planning is essential to ensure minimal losses during the implementation stages and steps must also be taken later to ensure that the losses are "replenished." This is crucial especially when development is in the vicinity of a protected or animal sanctuary, a forested area, or a catchment area. Ecological losses should be minimized and suitable protection put in place for the conservation of flora and fauna.

16.2.3 Risk of Water Pollution

Water quality is important for economic, ecological, aesthetic, and recreational purposes. Changes in water quality may affect its aesthetic value or even prevent some uses of the water. During construction, the potential for soil erosion and risk to water quality is greatest when removal of vegetation for initial clearing and grading activities exposes soil and makes it susceptible to erosion. The impacts and risks are greatest during the rainy season where extensive land clearing can increase sediment load into the rivers from erosion of the exposed soil.

16.2.4 Risk of Air Pollution

Activities of major concern for air quality are the burning of waste, the emission of fumes and smoke, and the release of chemical impurities such as heavy metals, acid and other toxic bases. Air quality impacts from construction include increased dust particulates in the atmosphere caused by grading, filling, removals, and other construction activities. Air quality may also be impacted by emissions from construction equipment and vehicles.

16.2.5 Risk from Noise and Vibration

Noise and vibration can be generated by various activities and equipment used in construction projects. Noise and vibration levels due to construction activities in the project area vary depending on the types of equipment used, the location of the equipment, and the operating mode. Adverse impacts resulting from construction noise and vibration are generally limited to areas adjacent to the project, and are temporary in nature.

16.3 How to Determine Risks

The first thing organizations involved in construction need to do is determine the environmental risks that they have to manage. Environmental risks are those risks that are associated directly and indirectly with the construction activities (Põder 2006). In the construction sector, the environmental risks can be one or more of the types described in 16.2 above. These can happen during the course of the construction, during the operation, or at the end of operation, as well as in abnormal or emergency situations such as during heavy rain or landslides. These environmental risks should therefore be taken into consideration at every stage of the project implementation, from conception to completion (Hickie and Wade 1997). A project can give rise to a number of environmental risks related to the activities of the various organizations involved in construction. Some risks will be directly within the organizations' control (e.g., direct risks such as air emissions and water discharges) and some will be of a nature that can be only indirectly influenced (e.g., the activities of raw material suppliers) (Olander and Landin 2005). As both types can lead to substantial environmental impacts, they should be assessed for significance. Such risks may be local, regional, or global, short or long term, with varying levels of significance. Having evaluated environmental risks for the significance it is then possible to prioritize actions that address issues relating to the construction operations. Table 16.1 shows the sequence for identifying environmental risks associated with construction.

16.4 How to Manage Construction Risks

The construction industry must minimize and manage the generation of pollution that may affect elements of the environment. To ensure that all reasonable and practicable measures have been taken, attention must be given to (a) the nature of the pollution or potential pollution and sensitivity of the receiving environment; (b) the financial implications of various measures that might have to be taken; and (c) the current state of technical knowledge and the likelihood of a successful application of the various measures to be taken (Lee and Fong 2002). For example, general soil erosion and the generation of sediment during construction activities cannot be entirely prevented but should be minimized (Zobel et al. 2002; Zobel and Burman 2004). Sound project planning can reduce the potential for erosion but control measures will always be necessary to reduce the impact of erosion both on-site and off-site. The control measures may consist of a combination of construction strategies, structural and vegetative measures, and soil stabilization techniques. For maximum effect, it is important that all of the control measures to be implemented are integrated into the site development plan (Tam et al. 2004). The complexity and extent of control measures required will depend largely on the magnitude and duration of the construction activity (Olander and Landin 2005). Overall there is a high

Table 16.1 Sequence involved in risk identification process

STEP 1. Identify construction type	STEP 2. Identify environment-related activities that can spawn risks	STEP 3. Determine environm-ental risks associated with each activity	STEP 4. Evaluate significance of the environmental risks identified	STEP 5. List all significant activities into a significant risks register	STEP 6. Prioritize the significant risks register. The most significant should be managed first
• Design of township, highway, or multistory apartment • Land clearing and earth work • Construction of hospital, school, or road	Examples of environment-related activities: • Consumption of natural resources • Removal of top soil • Removal of vegetation • Discharge of waste water, waste oil, building waste, etc. • Consumption of electricity • Emission of dust and other particulates	Examples of environmental risks: • Depletion of natural resources • Loss of soil fertility • Loss of flora and fauna • Loss of habitat • Soil erosion • Visual impact • Water pollution – waste, siltation • Air pollution – dust and particulates • Global warming • Noise pollution • Flash floods Link between activities and risks is similar to "cause and effect"	• Using established methodology and evaluation criteria appropriate to the construction sector • The methodology can be qualitative, quantitative, and semi-quantitative • The evaluation team should have a common understanding of the methodology and application of the criteria • Application of the methodology and evaluation criteria should be consistent throughout the process	• The evaluation process should result in a significant risks register • The register leads the organization to the following: a. The activities, products, or services that need to be managed in order to reduce the environmenal risks b. The activities that are covered under legal and other requirements c. The types of work that require specially trained personnel in order to prevent environmental risks	• It is critical to prioritize within the register to ease the management process • Priority should be based on significance in terms of the environment and legal compliance • Identify measures that can be implemented to prioritize and assuage the risks • The final register will guide the organization in setting its environmental policy and objectives

level of awareness and commitment with regard to protecting the environment among contractors and others involved in the construction industry. Some have already taken measures to comply with all regulations regarding water pollution, noise control, and dust emissions. In some cases, additional initiatives have also been adopted, such as energy conservation and recycling of materials (Rodríguez et al. 2007; Tam 2008).

16.5 Case Studies

16.5.1 Case Study 1 Project: Construction of High-Rise Apartment Buildings at Bukit Gambier, Penang

During this project, quite extensive site clearing took place before actual construction commenced. Environmental risks were incurred during the mobilization, site clearing, and earthworks that required clearing of the ground ready for development. Most of the 8.1 acres of land were located on slopes with contours ranging from 20 to 55 m in elevation and gradients of 5° to >26°. Once the project site had been cleared of vegetation, the disturbed soil surface lost its cohesion. The top soil became very loose as a consequence of tree uprooting, bulldozing, and surface soil disturbances. The increased susceptibility of the soil particles to sheet erosion or displacement by wind or rain was a major concern, since this would increase the volume of silt content in surface runoff during heavy rain. As a countermeasure, surface runoffs and storm water were channeled to an earth drainage system and temporary siltation pond with a perimeter earth drain built to prevent overflow of surface runoffs into adjacent areas. In addition, earthworks were scheduled to be carried out mainly during the dry season and the exposed surface was covered with plastic sheets to avoid rain-wash and siltation/sedimentation. Despite these measures, however, the impacts arising from the project site clearing included the accumulation of overburden, exposed soil leading to extensive silting as a result of surface runoff, and the concomitant degradation of water quality, as well as noise and air pollution from on-site vehicles (Lee and Fong 2002). During drier seasons, exposed soil can also lead to a significant increase in dust suspended in the atmosphere.

16.5.2 Case Study 2 Project: Construction of High-Rise Housing at Bayan Lepas, Penang

The project comprised a total area of 14.1 acres (5.7 ha) at Bayan Lepas with terrain ranging from 10 to 80 m in elevation. The development concept for the proposed project consisted of a medium density residential development of less than 22 units

per acre. Since runoff from construction sites can contribute significant sediment loads to receiving water, effective erosion and sediment control at the construction site were part of the measures to manage storm water. In order to minimize risks to the neighborhood from the construction, planning of the development followed an environmentally friendly approach by minimizing cut and fill and maximizing slope protection measures. In addition, sediment control practices were implemented to trap detached soil particles moved by rain, surface run-off, or wind. By implementing Erosion and Sediment Control Practices (ESCP) on site throughout the construction period, the erosion rates were minimized.

16.5.3 Case Study 3 Project: Development of Marina and Jetty Infrastructure at Church Street Pier, Pengkalan Weld, Penang

The development site was located in the midst of a regional commercial and tourist hub with existing transportation, communication, and energy infrastructure well in place. There were two types of construction—land-based and sea-based. Site clearing and earthworks within the project area were very limited because the site was primarily an open area covered partly by a concrete platform with some grassy patches and tarred roads. The main activity, was the demolition of the existing pier followed by construction of a new pier, a marina building, and ancillary buildings and structures. The demolition waste included asbestos, zinc planks, wood beams, wiring, glass, and pipes. Waste from the demolition was carefully segregated and disposed of according to type, since major risks are involved with hazardous materials from demolition and associated safety and health issues. Other hazardous waste, such as used oil, was kept in labeled containers to be sent to the designated treatment facility. The sea-based construction including piling disturbed the seabed and released pollutants, leading to an increased water pollution level locally.

16.5.4 Case Study 4 Project: Demolition of Part of an Existing Building Structure and Renovation of a Hotel in Batu Ferringhi, Penang

The project plan followed Penang state's principle strategy of developing, protecting, and optimizing land usage in a sustainable way. The project was viewed as an effort to optimize land use as it involved modification of and additions to a commercial development (a hotel) within an existing area and without further expansion. A risk assessment ascribed risk to those activities closely associated with solid waste from the demolition, water pollution of the nearby rivers from the clearing

and earthworks, and construction (Tam 2008). This type of development normally imposes less risk than usual; however the local authority had given instructions for an environmental impact assessment to be conducted nonetheless.

The construction site was small and vehicle emissions and dust formation were confined within the construction area by natural vegetative barriers. Vehicles were encouraged to move slowly to reduce air emissions and dust formation. Dry, exposed soil was also sprayed using a water bowser to curb dust formation.

16.5.5 Case Study 5 Survey

A total of 175 adult members of the public were given a questionnaire about the risks posed by the construction industry. This survey revealed that the majority were very much aware of the various risks faced by people, plants, and animals, as well as the risks to the environment as a result of construction activities. For example, most of them agreed that construction activity can cause soil erosion, floods, loss of natural resources, reduction in soil quality, and reduction of rain absorption area. The majority also recognized that loss of habitat, death, and destruction are some of the effects on plants and animals. Similarly, most of them agreed that animals may move away from an area where construction takes place. In addition, a large number of respondents also acknowledged that two risks faced by humans are health problems due to dust released during construction and feeling discomfort due to the noise from construction. However, only around one third of the sample considered that murky water caused by soil erosion from construction sites could have a negative effect on fish in rivers.

In general, most of the people surveyed held similar perceptions about construction risks irrespective of their academic or social background. One notable exception, however, was educational level: Among the sample who responded to this survey, those who had completed university education obtained a mean score of 63.09 for construction risk awareness. Those who were educated up to pre-university level, on the other hand, obtained a corresponding mean score of 59.68. This difference is statistically significant as shown by the p value of .01 in the independent samples t-test analysis conducted. This implies that university education helped improve awareness of construction risk.

16.6 Research on Risks Related to Construction

Although Malaysia has developed expertise and tools such as environmental auditing and environmental impact assessment to help quantify impacts and risks, it is hardly keeping up with the pace of development we are currently experiencing (Lee and Fong 2002). To date, only limited research has touched on how to

integrate the identification, assessment, and management of construction-related risks to the environment. Measures to eliminate or assuage these risks must be properly identified and formulated at the outset of the project planning process to include engineering, geotechnical, and architectural inputs, among others (Eom and Paek 2009). Research approaches by Eom and Paek (2009), Tam et al. (2004), Shen et al. (2005), Li et al. (2005), Cheung et al. (2004), and Chen et al. (2005) can be reviewed and adopted where suitable. However they are not without drawbacks, because their construction risk evaluations are based on the availability of guidelines.

Other research arbitrarily and inadequately identifies environmental impacts without taking account of site selection and building location. This leads to inaccurate conclusions as a result of generalized, skewed judgments. Dione et al. (2005) conducted a survey of multiple construction companies, and the companies showed concern about the possible implications of environmental risks resulting from their projects. However, there still needs to be more emphasis on identifying and mitigating such risks.

In order to maintain control over the risks incurred from construction, it is imperative for aspects of construction that create these risks to be explicitly defined. Research to date is still inadequate to do this systematically, and it is also not yet possible to assess the level of risks or to prioritize measures to assuage these risks. An environmental management plan (EMP) is an integral part of assessing the impacts of a construction project, and yet during the monitoring of environmental matrices, many of the impacts and risks remain unmitigated (Saunders and Bailey 1999). Another research consideration is to link the practice of environmental impact assessment with environmental management plans, environmental auditing, and environmental monitoring to strengthen efforts to protect the environment from the insensitivities of construction (Nawrocka and Parker 2009).

16.7 Conclusion

The construction industry is characterized by a high degree of fragmentation, with numerous individual participants each pursuing singular interests on a project-by-project basis. Construction activities by their very nature cause disturbances or risks to the environment. However, these risks can be identified following simple procedures, and measures can be implemented to mitigate them. Little research has been conducted on the effect of construction on the environment yet there are steps and guidelines available to assist the industry in minimizing risks to the surroundings.

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