



# Sustainability Factors and Performance

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## Abstract

A Transportation infrastructure projects often involve the considerable land use and huge resource that can cause serious impacts to the environment and social dislocation. Hence, implementation of sustainable factors is essential. This paper attempts (1) to review infrastructure project sustainability factor and performance, and (2) to propose a framework of relationship between the sustainability factors and performance for railway projects in Malaysia. The results from the literature show that sustainability factors and performance can be categorized under environment, economic, social, engineering/resource utilization and project management.

**Keywords:** Transportation; infrastructure project; sustainability factors; sustainability performance

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## 1.0 Introduction

The concept of sustainable infrastructure development has emerged since the Brundtland Report on 1987. The report defines sustainable development “meets the needs of the present without compromising the ability of future generations to meet their own need”, (Lim, 2009). According to Huang and Yeh (2008), the importance of sustainable infrastructure development is that it has a significant impact on the environment, economy and society. For instance, disturbance of human life and ecosystem resulted from construction and regeneration of infrastructure project development. Furthermore, infrastructure project development presents numerous challenges such as projects are time consuming, costly, and not always sustainable (Lothe, 2006).

Previous research in the field of sustainability infrastructure development has defined the term sustainability in a number of ways. The United Nations ESCAP (2006) defines sustainable infrastructure as infrastructure in harmony with the continuation of sustainability in the economy and environment by designing and maintaining buildings, structures and other facilities with an eye towards resource conservation over the life of the infrastructure. National Research Council of the National Academies, (2009) has referred infrastructure sustainability as a lifeline system that enables meet the needs of current and future generations through cost-effective, physically resilient, socially equitable and environmentally viable.

Sustainability of infrastructure transportation development is defined through it impacts on the economy, environment for and social benefits; measured by system efficiency and effectiveness (Khalid et al., 2012; Jeon & Amekudzi, 2005). On the other hand, Amekudzi et al. (2009) expressed sustainability of transportation development as a safe, efficient accessibility and improve economic productivity without negatively impacting the natural environment.

Implementation of sustainable concept in infrastructure projects development is crucial because it has a great impact on surroundings and involves many parties (Bueno et al., 2013; Jeon & Amekudzi, 2005; Litman, 2007). Nevertheless, current literature study shows that less attention and effort have been done on the sustainable development of the transportation system particularly on railway projects (Adnan, 2012; Naidu, 2008) which may be harder to understand from a sustainability perspective by multiple stakeholders (Dasgupta & Tam, 2005). This has resulting pollution of the environment, greenhouse gas emissions, fatalities and injuries, biological and ecosystem damage, project delays, poor quality, States. (Lim, 2009; Transportation Research Board of the National Academies, 2005). As for Malaysia, infrastructure projects proposed have often not incorporated sustainable development principle; hence, the result has been project failures and stranded facilities (Naidu, 2008).

The importance of implementation sustainability factors is that it can affect the project sustainability performance (Lim & Yang, 2007; Transport for New South Wales, 2012; Ugwu & Haupt, 2007; Vanegas, 2003). Apart of that, sustainability factors also facilitate stakeholders, owners and engineers measuring the progress towards sustainable development by comparing the performance achieved with the intended performance (FIDIC, 2004). Hence, this paper attempts (1) to review transportation infrastructure project sustainability factors and performance, and (2) propose a relationship framework between

sustainability factors and performance for Malaysia railway infrastructure projects.

## **2.0 Literature Review**

In order to meet the need towards sustainable development, sustainability assessment systems have been implemented by the construction industry (Clevenger et al., 2013). Recently, several sustainability infrastructure assessment systems have been developed or are under development to measure the sustainability of infrastructure projects (Clevenger et al., 2013; Lim, 2009). They are usually created by the governmental institution, non-governmental institution, and sometimes in collaboration with academia. These systems use different techniques for determining sustainability emphasizing different sustainable factors (Martland, 2012).

The New South Wales Transport Division is the Australian governments' institution that has developed a Transport Project Sustainability Framework to ensure that their transportation system is sustainable over time and, environmental and sustainability performance is continually improved. The New South Wales Transport division focuses on the three spheres of sustainability i.e. environmental, social and economic that to be integrated during the project planning, development and delivery. The sustainability factors under environmental category consist of GHG emissions, water, pollution control, noise management, resource management, waste management, material consumption and biodiversity. The social category comprises stakeholders' relationship, communities/public acceptance and heritage conservation while corporate sustainability is under the economic category (Transport for New South Wales, 2012).

On the other hand, INVEST is an assessment system that provides a list of sustainable factors best practices to be incorporated into transportation project (Clevenger et al., 2013; Culp, 2011). INVEST was developed by Federal Highway Administration (FHWA), United States and launched on 2012. The sustainability factors of INVEST is designed to address sustainability throughout the project stages namely; planning stage, project development stage, operation and maintenance stage. The INVEST sustainability factors consist of noise quality, ecology and biodiversity, visual impact, waste management, energy and carbon emissions, erosion and sediment control, flora and fauna, health and safety, life cycle cost, cultural heritage, public access and inter-modality of transport (Culp, 2011).

Lim (2009) in his study has identified 23 critical sustainability factors specific for Australian road infrastructure projects. These are air quality, water quality, noise and vibration, erosion and sediment control, flora and fauna, environmental and social impact assessment, life cycle cost, project risk, cultural heritage, inter-modality of transport, functional performance of physical asset, community involvement and public governance, liaison with client, liaison and collaboration with internal stakeholders, type of contract and project governance, compliance with contract and project specifications, hazardous goods, road user safety, road worker safety, quality control, supply chain management, waste management and recycling. These 23 critical sustainability factors are clustered into ten (10) categories; environmental, economic, social, engineering, community engagement, relationship management, project management, institutional sustainability, health and safety,

resource utilization and management. According to Lim and Yang (2007), every infrastructure project deliverables stages must be guided by the principles of sustainable development to ensure the project is sustainable.

Apart of that, CEEQUAL is also an assessment system that aims to improve sustainability in infrastructure projects of civil engineering works and public realm project by providing an incentive to the designer, client and contractors to adopt best environmental and social practices (Cartwright, 2008). The sustainability agenda in CEEQUAL Assessment Manual consists of 12 key sustainability factors, namely: land use, project environmental management, ecology and biodiversity, landscape, archaeological and cultural heritage, water issues, use of materials, transport, waste, nuisance to neighbors, energy and community relations (Cartwright, 2008; CEEQUAL Scheme Management Team, 2004).

Table 1: Matrix of sustainability factors of transportation infrastructure projects

Theme	Factors/criteria	New South Wales (2012)	INVEST (2012)	Lim (2009)	CEEQUAL (2008)	Green LITES (2008)
Environment	Land use / site selection				✓	✓
	Water quality	✓		✓	✓	✓
	Air quality			✓		
	Noise quality		✓	✓		
	Ecology & Biodiversity	✓	✓		✓	
	Visual impact		✓		✓	
	Waste management	✓	✓	✓	✓	
	Energy & Carbon emissions	✓	✓		✓	✓
	Pollution control	✓				
	Erosion & Sediment control		✓	✓		
Flora & Fauna		✓	✓			
Economic	Life cycle cost	✓	✓	✓		
	Project risk			✓		
Social	Cultural heritage		✓	✓		
	Public access		✓			
	Health and safety		✓	✓		
	Stakeholder relationships			✓	✓	
	Inter-modality of transport		✓	✓	✓	
	Site access/development				✓	
Engineering/ Resource utilization	Material type & availability		✓		✓	✓
	Constructability	✓				
	Reusability		✓	✓	✓	
	Quality control/assurance		✓	✓		
Project administration	Functionality performance of physical asset			✓	✓	
	Type of contract			✓	✓	
	Procurement method				✓	
	Project risk			✓	✓	

All of the developed sustainability factors reviewed above generally have a similar aim that is to encourage an organization to include sustainable practices in their company's

strategy and daily work practices.

Another sustainability assessment system for transportation infrastructure projects is GreenLITES. GreenLITES is a sustainability assessment system aimed to encourage development of no negative environmental effects, little disruption to society, suitability of design, low cost construction or no maintenance highways, provision of safe multimodal means of transportation, a medium for the spreading of information and funding for research (Clevenger et al., 2013; McVoy et al., 2010). It was developed by New York Department of Transportation (NYSDOT) in 2008 to align better sustainability efforts in planning, design, construction, and maintenance operations with long-term needs (McVoy et al., 2010). The sustainability factors of this system are environment, economy, social, sustainable Sites, water quality, material and resources, innovation, energy and atmosphere (Clevenger et al., 2013).

Table 1.0 presents the matrix of sustainability factors of transportation infrastructure projects based on reviewed literature. Generally, the sustainability factors can be categorized under several theme i.e. environment, economic, social, engineering/resource utilization and project administration.

### **Sustainability performance of infrastructure projects**

Implementation of sustainability factors across the project life cycle phase is a crucial aspect in achieving the goal of sustainable development (Shen et al., 2007). According to Vanegas (2003), the degree of project sustainability performance such as a solution of the problem, a satisfaction of the client's need/objectives, clear term of instruction, etc., is highly influenced by the implementation of sustainability factors. Conventionally, time, quality and cost have long been defined as the basic criteria for measuring construction project performance (Chan & Chan, 2004). Nevertheless, Ugwu and Haupt (2007) in their research findings show that the implementation of sustainability factors has led to sustainable project performance such as better decision-making, minimize wastage, efficient project delivery, avoid delays as well as minimize constructability related-problems (rework, claim, etc.). Lim (2009) identified that implementation of sustainability factors in road projects can minimize pollution and environmental impacts, community/public acceptance, fit for purpose and quality, minimize maintenance and operation cost, minimization risk, completion on time, protect cultural heritage, safe construction etc.

Moreover, Transport for New South Wales (2012) has also identified the advantages of sustainability factors implementation to their project performance such as safe construction, noise and vibration minimization, air quality and dust suppression, prevention of land contamination and degradation, protection of water quality, reduction of construction materials footprint, minimization of carbon footprints and energy use, minimizing water usage, maximizing rainwater harvesting and re-use and meeting waste management standards.

Table 2.0 presents the matrix of identified sustainability performance of infrastructure projects from the previous studies that related to environmental, economic, social, engineering/resource utilization and project management.

Table 2: Matrix of sustainability performance of infrastructure projects

Theme	Sustainability Performance	New South Wales (2012)	Lim (2009)	Ugwu & Haupt (2007)	Vanegas (2003)
Environment	Minimize pollution & environmental impacts		✓		
	A balanced development		✓		
	Community/public acceptance		✓		
	Protect native/aquatic wildlife		✓		
	Meeting waste management standards	✓			
	Maximizing rainwater harvesting and re-use	✓			
	Minimizing carbon footprints and energy use	✓			
	Protection of water quality	✓			
	Prevention of land contamination and degradation	✓			
	Air quality and dust suppression	✓			
Noise and vibration minimization	✓				
Economic	Fit for purpose & quality		✓		
	Minimize maintenance & operation cost		✓		
	Minimization risk		✓		
	Completion on time		✓		
Social	Protect cultural heritage		✓		
	Save travel time & vehicle operating cost		✓		
	Public acceptance		✓		
	Open & transparent community involvement		✓		
	Promote interagency collaboration		✓		
	Safe construction	✓	✓		
	Public acceptance		✓		
	Minimize health & safety risk		✓		
	Better decision making			✓	
Clear term of instruction & approval within time				✓	
Engineering/ Resource utilization	Enhancement of infrastructure life span		✓		
	Achievement of project objectives		✓		
	Long-lasting & high quality products		✓		
	Saving maintenance cost		✓		
	Uninterrupted material supply		✓		
	Reduction cost		✓	✓	
	Increase design innovation			✓	
	Completion on time		✓		
Minimization waste	✓	✓	✓		
Project administration	Completion on time		✓		
	No dispute		✓		✓
	Achieves client's objectives		✓		✓

### 3.0 Methodology

This study is purely based on the literature review. It reviews the theoretical aspects of research work of sustainability factors and performance in infrastructure projects. The reason of undertaking literature review as the main methodology for the study is to establish the depth and breadth of the current state of sustainability knowledge in the area of sustainable infrastructure development, particularly on transport infrastructure project. Besides, it also helps to establish the conceptual framework for Malaysia sustainable railway infrastructure project to guide the study in subsequent stages.

### 4.0 Findings and Discussions

#### Propose research framework

Figure 1 proposes a conceptual framework of the relationship between sustainability factors and performance for railway infrastructure project in Malaysia.

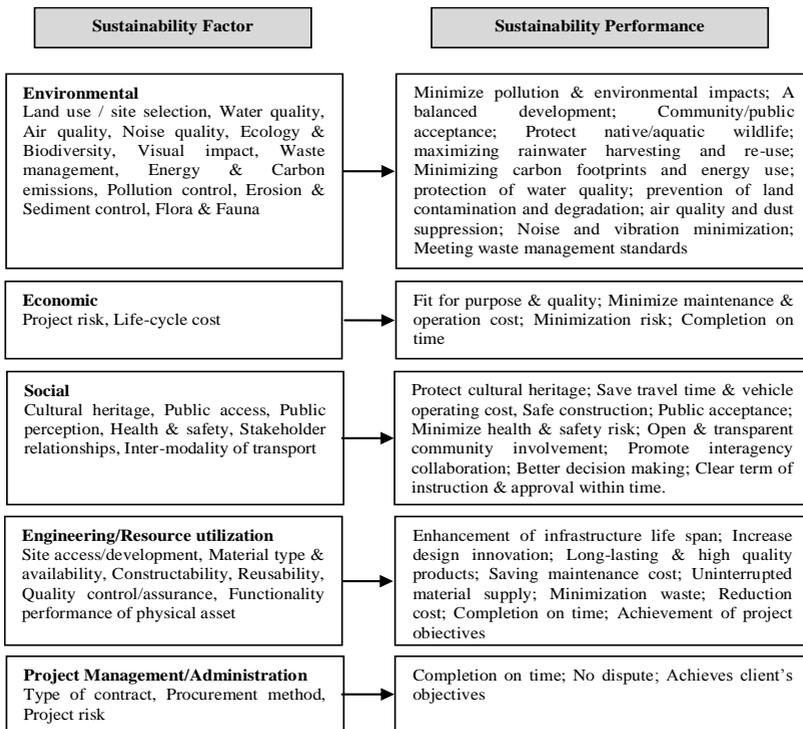


Figure 1: Propose a Conceptual Framework of Relationship between Sustainability Factors and Sustainability Performance for Railway Infrastructure Project in Malaysia.

This has been developed based on the preliminary literature review. The conceptual framework consists of two major components: Sustainability Factor and Sustainability Performance. The first component is sustainability factors. Drawing from the literature review, there are 27 sustainability factors specific to transportation infrastructure projects have been identified, compiled and distributed under five categories. These sustainability factors embrace the issues of environmental concerns, economic empowerment, social needs, Engineering/Resource utilization and Project Administration.

The second component is the sustainability performance. For each category of the transport sustainability factors, the sustainability project performance also has been identified. These components demonstrate the influence of implemented sustainability factors to sustainability performance in infrastructure projects. Vanegas (2003) articulates that, it is important to incorporate sustainability factors because it contributes in different ways of sustainability project performance. Hence, given the above, these two components (i.e. sustainability factor and sustainability performance) are crucial in the development of a sustainability performance guideline of railway infrastructure projects. The purposes of this framework are to help to see clearly the variables of the study and as a general framework for data collection and analysis.

## **6.0 Conclusion**

This paper attempts to review, synthesize and developed an integrated framework of the relationship between Sustainability Factors and Sustainability Performance for Railway Infrastructure Project in Malaysia based on the experience learned from various researchers, the governmental and non-governmental institution of different countries. There are 27 sustainability factors specific to transportation infrastructure projects have been identified that embrace the issues of environmental, economic, social, engineering/resource utilization and project administration. The reviews also show that the influence of implementation sustainability factors to project performance such as minimize pollution, minimize maintenance, reduce operational cost, safe construction, etc.

According to Joumard and Nicolas (2010), the advantage of these sustainability factors is to provide data for managing the construction project (evaluation, performance, control). Therefore, it is necessary that users should understand the assumption, perspective and limitation when using the sustainability factors (Litman, 2007). The outcomes of the study should be useful to promote the sustainability strategies implementation, particularly in Malaysian railway project. In considering these variables, a further empirical research is needed. A combined approach of two methodologies (e.g. qualitative case-study and quantitative survey data) would be useful for data collection prior further validation processes. The outcomes of the research study would provide insight into the Malaysian infrastructure project development and will offer a guideline especially to the railway infrastructure project stakeholders in Malaysia that are looking forward to enhancing sustainability performance of railway infrastructure projects.

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