Tropical Environment Elements for Green Highway Assessment

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ABSTRACT

A highway is a main public road that connects towns and cities. Subsequently, a green highway is the transportation corridor which is based on a relatively new concept of roadway design that integrates major cities and towns. A green highway also provides more sustainable construction techniques and approaches to maximise its lifespan. The need for evaluation of sustainability and green development requires an assessment system of a green highway. An assessment system is required to evaluate the sustainability of a highway for construction projects. The aim of this study is to explore the environmental elements for green highway in the tropical climate of Malaysia. The objective is to identify the essential fundamental environment elements in a tropical climate for green highway assessment. The methodology is using desk study. This study has discovered eight fundamental environment elements of the green highway.

Keywords: *tropical environment, green highway, assessment system*

INTRODUCTION

Highways play a vital role in the functioning of human society (Brown, 2003). From ancient times to the present, highways have functioned as the arteries of human civilisation providing pathways for human settlement, commerce, culture, and adventure (Brown, 2003). In the meantime, highways not only provide the means for commerce, but also provide access to more natural landscapes for multiple values and leisure activities (Brown, 2003).

The construction of highways directly or indirectly caused adverse impact to the environment (Gambatese & Rajendran, 2005). The construction of highways would cause negative impacts on the surrounding ecosystem and overall environmental quality (Bryce, 2008). Dhakal and Oh (2011) also stated that a highway system causes environmental impacts, financial inefficiency, natural resources exploitation, and adverse social repercussions.

Highway development has vastly accelerated in recent years from foot tracks to modern highways (Mlambo, 1994). Building modern highways requires new technologies and advance technique. This innovation has been establish to reduce the impact on the environment (Rooshdi et al., 2014). To develop advance highway infrastructure, it is significant to include best practices that reduce the impacts of highway construction on the natural environment (Bryce, 2008).

Moreover, green highway approaches have been introduced in developed countries such as the United States and the United Kingdom to improve the quality of the environment. A green highway takes into account a high consideration to improve the environment, transportation system development, ecosystem, urban growth, public health and also the surrounding communities (Ismail, M.A., *et al*., 2013; Zakaria *et al*., 2012).

Problem Statement

The contemporary study of sustainable issues in Malaysia mostly concentrates on green buildings. The Green Building Index (GBI) was newly launched as a sustainable rating system for residential and commercial buildings. Unfortunately, GBI only evaluates sustainability of buildings

that restrict the consideration on sustainable transportation infrastructure, predominantly highways (Rooshdi *et al.*, 2014). This shows that Malaysia is still lacking on the assessment of green transportation infrastructure. Presently, the area of transportation infrastructure towards green highways has been a concern of Lembaga Lebuhraya Malaysia.

Iskandar Malaysia Transport Council (IMTC) developed by Iskandar Malaysia has proposed Pengangkutan Hijau Iskandar Malaysia (PHIM) in order to establish plans, strategies and policies related to green Iskandar Malaysia (Iskandar Malaysia, 2011). PHIM intends to spearhead projects related to sustainable environment. In the Iskandar Malaysia Plan, Green Iskandar works very closely with state and federal agencies to achieve Iskandar Malaysia's green objectives (Iskandar Malaysia, 2011). Moreover, it also lives up to the national aspirations. Nevertheless, until now sustainable transportation infrastructure rating system to evaluate the accomplishment of the initiative in local tropical climate has not been set up yet. Therefore, an extensive research is needed to contribute towards Malaysia's transportation infrastructure.

A developed country such as the United States has established evaluation tools for transportation infrastructure such as the Green Roads Rating System (Greenroads) (Soderlund, Muench, Willoughby, Uhlmeyer, & Weston, 2008) and Building Environmentally and Economically Sustainable Transportation Infrastructure-Highways (BE^2ST In-Highways) (Recycled Materials Resource Centre & University of Winconsin-Madison, 2010). These tools are solitary for the western climate with the four seasons. However, these rating systems are less suitable for Malaysia's tropical climate. These tools need extensive research in order to adapt to other different climates (Bryce, 2008). Therefore, there is a need for extensive research on the green highway assessment system for tropical climate.

Research Aim

The aim of this study is to explore the environmental elements for a green highway in the tropical climate of Malaysia.

Research Objective

The objective of this study is to identify the essential fundamental environment elements in a tropical climate for the green highway assessment.

Significance of Study

This study is significantly related to the National Green Technology Policy of the Malaysian government. The National Green Technology Policy in its objective number 4 highlights on sustainability development to improve the quality of life and preserving the natural resources and environment for future generations (KeTTHA, 2014). Thus, for short term goals, the government through the National Green Technology Policy Goals encourages local research institutes and institutions of higher learning to expand research, development and innovation activities on Green Technology towards commercialisation through appropriate mechanisms (KeTTHA, 2014). This study is consistent with this policy in order to contribute to the research of sustainability in transportation infrastructure.

LITERATURE REVIEW

Green technology is the development and application of products, equipment and systems used to conserve the natural environment as well as resources. This technology also minimizes and reduces the negative impact of human activities (KeTTHA, 2014). The Ministry of Technology, Green Technology and Water had launched the National Green Technology Policy in 2009 as a driver to accelerate the national economy and promote sustainable development in the 10th, 11th and 12th Malaysia Plan (KeTTHA, 2014). The objective of the policy is to ensure the sustainable development and conservation of the environment. One of the areas emphasized in this Green policy is the transportation sector that mainly focuses on the transportation infrastructure. Furthermore, the 4th strategic thrust highlighted the crucial research, development, innovation and commercialisation (RDIC) on green technology.

Tropical Environment

Tropical environment is a non-arid climate having an average temperature above 18°C (Maps of World, 2015). Examples of tropical climates are rainforests, Savanna and Semi-arid. Tropical climates are known as hot and humid weather conditions. Sunlight and excessive rainfall are characteristics of the tropical climate which helps in the growth of luxuriant vegetation. Countries besides Malaysia that have a tropical climate are Indonesia, Thailand, Singapore, Laos, Vietnam, Brunei, Myanmar, Cambodia, and Philippines (Maps of World, 2015).

According to Sham (1983), Malaysia experiences equatorial climate which is hot and humid throughout the year. Malaysia records an annual high temperature of between 26^{o}C to 27^{o}C. The temperature is different in the highland area like Cameron Highlands which experiences a lower temperature of about 18^{o}C. Besides that, Malaysia receives heavy rainfall of about 2000 mm to 3000 mm per year.

The Ministry of Science, Technology and Innovation (MOSTI) characterises the features of the climate of Malaysia as uniform temperature, high humidity and copious rainfall. Winds are generally light. Situated in the equatorial doldrums area, it is extremely rare to have a full day with a completely clear sky even during periods of severe drought. On the other hand, it is also rare to have a stretch of a few days with completely no sunshine except during the northeast monsoon seasons (MOSTI, 2013).

The characteristics for tropical climate are discussed below:

1. Wind flow

   Though the wind over the country is generally light and variable, there are some uniform periodic changes in the wind flow patterns according to the months of the year. The southwest monsoon season is from the end of May until the end of September. The northeast monsoon begins in early November and ends at the end of March. There are two shorter periods of inter-monsoon seasons (MOSTI, 2013).

2. Temperature

   The tropical climate experiences a high temperature throughout the year. The mean annual temperature is about 26°C to 27°C. Malaysia experiences a small annual temperature range because the temperature is rather even throughout the year. Besides that, Malaysia receives sunshine throughout the year and humidity of the air is high, at about 85%. The sky that is covered by thick clouds and the nature of islands that are surrounded by the sea also contributes to the small annual temperature range (Sham, 1983).

3. Rainfall

   The seasonal wind flow patterns coupled with the local topographic features determine the rainfall distribution patterns over the country. In the case of Malaysia, during the northeast monsoon season, the exposed areas like the east coast of Peninsular Malaysia, Western Sarawak and the northeast coast of Sabah experience heavy rain spells. On the other hand, inland areas or areas which are sheltered by mountain ranges are relatively free from its influence. It is best to describe the rainfall distribution of the country according to seasons (MOSTI, 2013).

4. Humidity

   The relative humidity of the air in a tropical climate is always high because the temperature always has a fluctuating range. Thus, the air always contains a lot of water vapour. Air humidity is the ratio between the water vapour present in the air and the amount of water vapour that air can hold at a certain temperature. Air humidity varies following the temperature. When the air temperature rises, humidity decreases and vice versa (MOSTI, 2013).

Green Highway

Green highway is defined as a roadway design based on a relatively new concept that incorporates transportation functionality and ecological requirements (LLM & UTM, 2014). It is also a roadway project that has

been designed and constructed to a level of sustainability that is substantially higher than the current practice (Muench *et al*, 2011). Zakaria *et al*. (2013) defined green highway as a roadway planned and designed with desires to integrate transportation functionality and ecological features.

Green highway is also synonym as a transportation corridor which uses low impact development tools, recycle materials, and local resources in transit right-of-way to meet the regulatory requirements for storm water management and highway design (Weinstein *et al*., 2008). Green highway could be defined as a system of roads that mitigate the negative impact on the environment to a level past minimum standards (Bryce *et al*., 2008). Overall, green highway is a relatively new concept and an initiative of the development infrastructure project to deliver a safe environment and ecological for the future.

Green Highway Approaches

There are several green highway approaches available which are Greenroads, Washington Internships for Students of Engineering (WISE), Building Environmentally and Economically Sustainable Transportation (BE^2ST), Greenroads Manual, and Malaysia Green Highway Index (MyGHI). Every approach has its own criteria and rating method of green highway. The criteria may be the same or different from one approach to another, depending on the climates.

Greenroads

Greenroads is the first green road rating system established in the United States in 2007. It is a voluntary third party rating system for road projects which seeks to recognise and reward the roadway projects. Greenroads consist of 54 credits in six elements. The elements of Greenroads are sustainable design, material and resources, storm water management, energy and environmental control, construction activities, and innovation. Each of these elements contains a number of credits. The credits are used to evaluate each one of the elements. The six main elements of green road are listed in Table 1.

Table 1: The element and sub element of greenroads (Source: Soderlund *et al*., 2008)

Main Element	Sub Element	Credit
Sustainable Design	Alignment Selection	1
	Context Sensitive Design	1
	Traffic Flow Improvement	1
	Roadway Safety	2
	Long-life Pavement Design	3
	Public Input	2
	Total Credits	10
Materials & Resources	Construction Waste Management	1
	Reuse of Pavement	2
	Recycle Content	4
	Life Cycle Analysis	3
	Regionally Provided Material	1
	Total Credits	11
Storm water Management	Storm Water Management	2
	Runoff Treatment	1
	Permeable Area	3
	Innovative Storm Water Technology	2
	Total Credits	8
Energy & Environmental Control	Cool Pavement	1
	Quiet Pavements	3
	Light Pollution	1
	Lighting Efficiency	1
	Eco-Viaducts	1
	Visual Quality	1
	Pedestrian Access	1
	Bicycle Access	1
	Environmental Management System	2
	Total Credits	12
Construction Activities	Reduce diesel emissions	1
	Reduce fossil fuel dependency	1
	Temporary storm water control	1
	Noise mitigation planning	1
	Paving emissions	1
	Paving construction quality	2
	Quality process	2
	Total credits	9
Innovation	Innovation	1-4
	Total credits	4
	TOTAL GREEN ROAD CREDITS	54

Washington Internship for Students of Engineering (WISE)

Washington Internship for Students of Engineering (WISE) is a concept written for the WISE programme. It was published in August 2008 at the University of Missouri United States. WISE provides five key areas of elements of a green highway. Figure 1 below shows the key areas of elements of green highways. The key areas consist of watershed driven storm water management, life cycle energy and emissions reduction, recycle, reuse and renewable, overall societal benefits and conservation and ecosystem management. A combination of the five keys areas establish the green highway fruition (Bryce, 2008). Each of the key areas defines the specific subjects that relate to the development of the green highways.

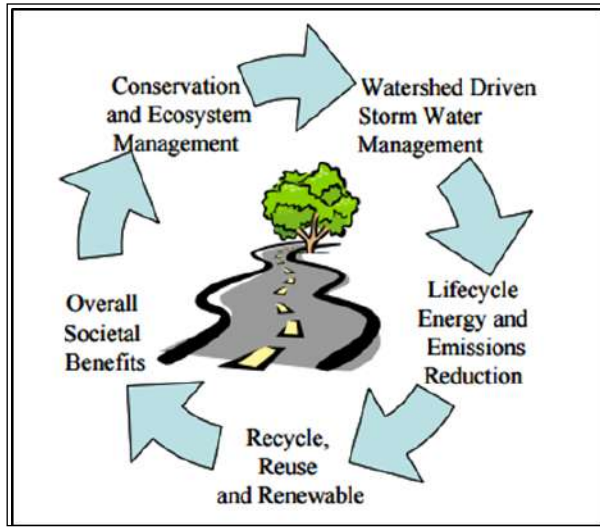

Figure 1: Key Areas of the elements of green highways (Bryce, 2008)

Building Environmentally and Economically Sustainable Transportation (BE2ST)

Building Environmentally and Economically Sustainable Transportation (BE^2ST) is a manual initiated by the University of Wisconsin in 2010. This manual is a data based programme which is linked to several publicly open sources. BE^2ST provides six main elements of green highway. Figure 2 below shows the elements and target value proposed by BE^2ST. The elements consist of material reuse or recycling, energy use, water consumption, global warming potential, life cycle cost and hazardous waste.

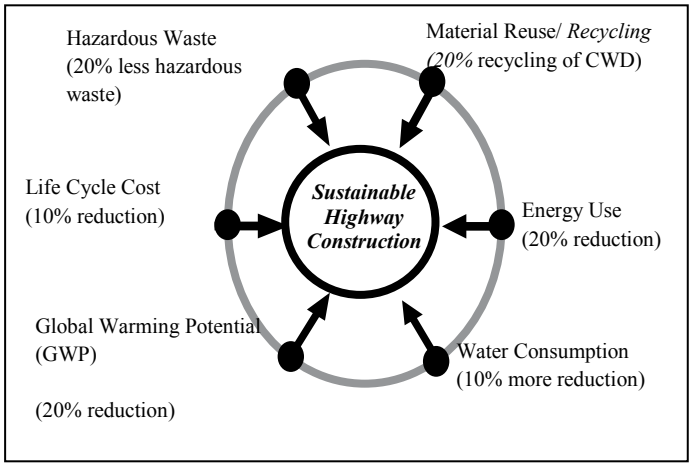

Figure 2: Elements and target value of the BE²ST in highways system (Recycled Materials Resource Centre & University of Winconsin-Madison, 2010)

Greenroads Manual

The Greenroads manual was published in 2011 by the University of Washington. It is an enhancement of the Greenroads that was published in 2007. This Greenroads Manual contains the details of each Project Requirement (PR) and Voluntary Credit (VC) that are included in the Greenroads Rating System. The Greenroads Manual could be used as a guideline during the design and construction phases. The Greenroads Manual helps to quantify the sustainable attributes of a roadway project. The Greenroads Manual developed five main elements of green highways such as Environment & Water, Access & Equity, Construction Activities, Material & Resources, and Pavement Technologies. Table 2 below lists all the elements, sub elements, factor score and percentage distribution by the Greenroads Manual.

Table 2: Elements, sub elements of green highway (Muench *et al*., 2011)

Elements and Sub Elements	Factor score	Percentage
Environment and Water Environmental Management System Runoff Flow Control Runoff Quality Stormwater Cost Analysis Site Vegetation Habitat Restoration Ecological Connectivity Light Pollution	21	19
Access and Equity Safety Audit Intelligence Transportation System Context sensitive Design Traffic Emission Reduction Pedestrian Access Bicycle Access Transit Access Scenic Views Cultural Outreach	30	28
Construction Activities Quality Management System Environmental Training Site Recycling Plan Fossil Fuel Reduction Paving Emissions Reductions Water Tracking Contractor Warranty	14	13
Material and Resources Life Cycle Assessment (LCA) Pavement Reuse Earthwork Balance Recycle Material Regional Material Energy Efficiency	23	21
Pavement Technologies Long-life pavement Permeable Pavement Warm Mix Asphalt (WMA) Cool Pavement Quiet Pavement Pavement Performance Tracking	20	19

Malaysia's Green Highway Index (MyGHI)

Malaysia has newly introduced Malaysia Green Highway Index (MyGHI) as an assessment on the green highway in 2014. Malaysia Green Highway Index (MyGHI) is a manual on the sustainability of roadway design and implementation of green construction practices. MyGHI identifies five elements to be developed for green highway as shown in Table 3. The elements are sustainable design and construction activity, energy efficiency, environment and water management, material and technology and social and safety.

Table 3: Elements and sub elements of green highway (LLM & UTM, 2014)

Elements and Sub Elements	Factor score	Percentage
Sustainable Design and Construction Activities Construction Management Plan Noise Mitigation Control Equipment and Machinery Efficiency Quality Management Context Sensitive Design Erosion and Sedimentation Control Alignment Selection	68	22
Energy Efficiency Management Policy Rest and Service Area Toll Plaza Compound and Car Park Interchange	64	21
Environmental and Water Management Environmental Management System Storm Water Runoff Quantity Storm Water Runoff Quality Ecosystem Protection and Preservation	60	19
Material and Technology Innovation and Technology Reduce, Reuse and Recycle Economical Materials & Pavement Erosion Control	51	16

Social and Safety Services and Facilities Economy Pollution Reduction Public Acceptance Environment Management Issue Innovation	67	22

METHODOLOGY

This study used the desk study method. Desk study is the collection of secondary data from internal sources, the internet, libraries, trade associations, government agencies, and published reports ("An Introduction to Research Methodologies," n.d.). From the desk study, literature review has been done to achieve the objective of this study. The literature review is based on the previous study by other authors. From that, the essential fundamental environment elements that are identified in the literature review will be included in the questionnaire for the next stage. For the next stage, questionnaires will be used to validate the results derived from the desk study.

CONCLUSION

There are many approaches established to define the elements of the green highway assessment. However, these approaches are suitable only for the western climate. From this study it was found that, there are eight essential elements needed to achieve a green highway such as sustainability design, material, energy efficiency, environment and pollution, technology and innovation, water management, access and equity, social and safety and life cycle costs.

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