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Weightage Factor for Criteria of Design and Construction for Green Highway

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Construction industry were one of the major contributor towards the environmental effect such as climate changes. Beside this the government is committed to reduce the CO_2 by 40 % in 2020. Construction is one of the major contributor on CO_2 emission. Hence, there is a need to reduce the impact on environment. The aim of this paper is to explain the methodologies for the determination of weightage for criteria of design and construction activities. The methodology processes begin with data collection by using questionnaires distribution the expertise who involve in highway development and green issues. There were 22 concessionaires with 140 respondents had been chosen to fill in the questionnaires. The data had been analysed using SPSS with factors analysis method. Results from the analysis show the weightage of each criterion were used to rank the criteria based on importance of the criteria in design and construction activities of highways. The result showed that the construction management had the highest weightage and follow by other 6 criteria.

1. Introduction

Fernández-Sánchez & Rodríguez-López, (2010) had stated that it is necessary to have new techniques and tools that will allow the environmental social an economics commitment to be met in building and civil engineering sector. Fernandez-Sánchez and Rodríguez-López (2010) and Bryce (2008) stated that most of the sustainable assessment tools were focus on building construction rather that infrastructure especially highway. However, Soderlund (2007) had mentioned that there were several developments of sustainable assessment tools for highway development in United State but not in tropical region especially Malaysia. Therefore, ever since Malaysia for the moment does not have any green highway rating system, it is therefore, needs criteria verification thoroughly. The development of these criteria is largely based on conducting a comprehensive literature review. Criteria related to sustainable design and construction activities in other green highway rating systems were chosen based on literature review. The criteria that had been selected and discussed among the expertise that involve in highway development to select the most appropriate criteria. They would share their experience, opinion and suggestion on the best criteria in sustainable design and construction activities. The criteria are developed from a complete process across the project life cycle and enable all project participants to understand and contribute to the project sustainability.
The comparison of 5 assessment tools had been taken from all over the world such United State, United Kingdom, Australia, Singapore and Malaysia. Most of the tools had 9 to 14 criteria that related sustainable design and construction activities. It had been summarised by Balubaid et al. (2015) and Raja Muhammad Rooshdi and Abd Majid (2014) that every tool had noted that design and construction activities had similar issues to be care about. The criteria are based on the green highway rating systems, highway project guidelines as well as a few related case studies. Soderlund (2007) and Greenroads (2012) studies has been used as a guide that has similar criteria in indicating the criteria for this study. Most of the criteria for sustainable design and construction activities from those assessments had similar factors such quality, environment, waste, water, and pollution. All factors are related to each other during design and construction stage. In

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summary, the preliminary criteria in Table 1 below had been taken out from other green highway rating systems are as table below. The criteria also considered the location, weather and method of construction to ensure those criteria will suit with Malaysia.

Table 1: Preliminary criteria

Categories	Criteria	Sub criteria
Sustainable design	Alignment selection	Design to reduce the area of undeveloped land
		Design to provide buffer between highway and high quality area
		Design to avoid impacts to environmental resources
	Context sensitive design	Design to avoid impact to socio economic resources
		Design to adjust highway features using design flexibility
		Design to utilize visual enhancement
		Design to reduce urban heat island effect
Construction activities	Construction waste management	Waste reduction
	Air pollution control	Greenhouse gas emission reduction
		Dust control
	Noise and vibration control	Noise and vibration mitigation
	Water management	Water consumption
		Water pollution control
		Temporary erosion and sediment control
	Equipment/machinery efficiency	Fossil fuel reduction
		Equipment emission reduction
		Paving emission reduction
	Quality construction	Quality management system
		Environmental training on-site
		Contractor warranty
	Construction maintenance	Site maintenance

2. Research Methodology

In order to develop the questionnaires, the criteria that had been carried from literature review and expert discussion were used. The questionnaires were distributed to the respondents in order to get the agreement level for each criterion. The feedback from the respondents will be analysed by using SPSS and the weightage that has been generated through factor analysis will be used to determine which criteria is the most important during design and construction of green highway. According to John W. Creswell (2013), questionnaires design provides a numeric description of trends, attitudes, or opinions of a population by studying a sample of that population. Questionnaires is used in this research to gather information and several steps are taken to design questionnaires for this research purposes including objectives of the survey, determined sampling group, designed the questionnaire, administered the questionnaire and results interpretation.

3. Data Collection

The survey questionnaires were distributed to several respondents to complete manually. These questionnaires were distributed to the respondents which are consisted of expertise in highway construction industry. There are 140 respondents, mostly from 22 concessionaires and Consultants Companies has been reached to have their feedback and justification for the data analysis. The questionnaires were distributed by hand and the informal interview also held during the survey. The informal interviews were organized regarding the questionnaires understandings and to avoid the discrepancies among the respondents. The location of data collection is around Kuala Lumpur, Selangor, and Johor area.

The questionnaire had been divided into two section: Section A for demographic and Section B for main criteria. The questionnaires survey contains nine (9) main criteria, twenty-one (21) sub-criteria, twenty-nine (29) elements description that have been collected from the literature and reviewed by expertise during pre-expert discussion stage. The main criteria had been divided into sustainable design and construction activities. Therefore, it had been coded as SD1 and SD2 for sustainable design and CA1, CA2, CA3, CA4, CA5, CA6, and CA7. Experts have responded to the survey to ensure the number and description of each criterion suitable with highway design and development in Malaysia.

According Krejcie and Morgan (1970), sample size can be determine by using table of determining sample size if the researcher target population. The questionnaire sample was designed on the table of determining sample size because the target population for this research is 22 concessionaires in Kuala Lumpur, Selangor and Johor Bharu. These three (3) city are the most focused area of the highway development in Malaysia. Each concessionaire was targeted to have 10 expertise to answer the questionnaires survey. It makes the population is 220 respondents. Based on table of determining sample size below, if the population is 220, the sample will be 140.

4. Data analysis

4.1 Demographic analysis

Based on the questionnaires survey that had been distributed, there are 83 % of the respondents were from concessionaire's company and the rest from consultants' company. Most of the respondents also had more than 10 y working experience and they were very experience with highway development. Since they had more than 10 y working experience with highway development, they were concern about green development in highway industry.

4.2 Factor analysis

A factor analysis was initially conducted on 29 items with oblique rotation (promax). However, three items were removed due cross loadings. The final model consists of 26 items. All tests are reported at the $p<0.05$ level (95 % confidence level). Means have been calculated using only the number of respondents who chose a rating point answer. Reliability test are done in the beginning of the section analysis due to check the reliability of data to be analysed.

This data set show Cronbach's Alpha is 0.922 with 29 variables. There is high internal consistency for the data set which the Cronbach's Alpha is more than 0.7 (Hair, et al. 2010). The data were analysed by using KMO and Bartlett's Test to test the sampling adequacy. The KMO ranges from 0-1 with higher values indicates greater suitability, and greater than 0.750 is much better. This KMO for this data is 0.790 and Bartlett's test is significant [$\chi 2$ (406) = 2100.448, $p < 0.001$] and therefore it shows that correlations between items are sufficiently large for factor analysis. As suggested by (Kaiser, 1974) where he recommends accepting values greater than 0.5 as acceptable. According to (Hutcheson & Sofroniou, 1999), the value of KMO between 0.7 until 0.8 are good.

The interpretation begins with the first variable on the first factor. This data had been divided into eight (8) main factor. There were 30 variables that had been analysed but three (3) items were removed due to not significance loading. The items were water disposal, water pollution control measure on site and provide noise measure plan. All three (3) items had 0.43, 0.38 and 0.38 respectively and it is less than 0.45 factor loading. Since this study had 140 sample size, therefore, the items that had factor loading less than 0.45. It was supported by guideline for identifying significant factor loadings based on sample size by Hair, Black, Babin, & Anderson (1998). There another one item which is reduce undeveloped land had been removed because it is only one factor in the last factor group, factor 8. The item had been removed because based on the discussion among the expertise during the focus group discussion. It is because the possibility to reduce undeveloped land in Malaysia, meanwhile Malaysia now are heading into development country. As mentioned by Hair et al. (1998), during the interpretation factor, the variables or factor could be evaluate those variable for possible deletion by considering on the variables contribution to the research. Therefore, the final model consists of 26 items.

Seven factors had eigenvalues over Kaiser's criterion of 1 and explained 68 % of the variance. The scree plot supported the Kaiser's criterion in retaining seven factors. Given the large sample size and the convergence of the scree plot and Kaiser's criterion on seven factors that were retained in the final analysis. The highlighted numbers in table 2 below shows the appropriate factor loadings for each criterion and it had been sorted accordingly based on their importance. The items that cluster on the same factors suggest that factor 1 represent construction management plan, factor 2 represent noise mitigation control, factor 3 represent equipment and machineries efficiency, factor 4 represent quality management, factor 5 represent context sensitive design, factor 6 represent erosion and sedimentation control, and factor 7 represent alignment selection.

Table 2: Factor loading for each criterion

Variables	Component							
	1	2	3	4	5	6	7	8
Provide cwmp	0.966	-0.150	-0.195	-0.222	0.085	0.097	-0.067	0.112
Method of waste minimization	0.728	-0.371	0.272	0.077	-0.118	0.228	-0.034	0.082
Use efficieny method	0.643	0.176	0.147	0.110	-0.138	-0.015	-0.035	-0.024
Site recycling plan	0.636	-0.118	-0.056	0.067	0.068	0.192	-0.026	-0.068
GHG emission reduction	0.597	0.283	0.094	-0.171	0.209	-0.140	0.052	-0.097
Dust control	0.541	0.236	-0.022	0.043	-0.079	0.051	0.212	0.183
Water tracking system	0.518	0.241	0.167	0.140	-0.003	-0.260	-0.232	0.054
Waste disposal	0.426	-0.204	0.139	0.033	-0.038	0.351	0.142	0.295
Water pollution control measures on site	0.388	0.169	-0.184	0.053	0.339	0.375	-0.088	-0.253
Use alternative construction methods	-0.077	0.893	0.019	0.012	0.176	-0.039	-0.092	0.058
Noise mitigation technique	-0.115	0.786	0.150	0.011	0.017	0.081	0.049	0.280
Operate stationary equipment	-0.078	0.709	0.179	-0.154	-0.251	0.174	0.288	-0.121
Paving emission reduction	-0.116	0.084	0.832	0.087	-0.017	0.069	0.056	-0.059
Fossill fuel reduction	-0.004	0.108	0.813	0.036	-0.098	-0.097	0.096	-0.102
Equipment emission reduction	0.122	0.173	0.618	-0.015	0.162	0.030	-0.156	-0.161
Site maintenancd	-0.024	-0.143	0.058	0.811	0.110	0.018	0.148	-0.032
Quality mgmt system	-0.225	-0.009	0.261	0.724	0.092	0.168	-0.251	0.101
Contractor warranty	-0.107	-0.121	-0.083	0.688	0.116	-0.237	0.475	-0.198
Env training on site	0.160	0.132	-0.035	0.678	-0.019	0.073	-0.150	0.172
Provide nmp	0.277	0.262	-0.278	0.375	-0.279	0.188	0.161	0.144
Adjust highway features	-0.010	0.056	-0.103	0.136	0.778	0.099	-0.241	0.170
Utilize visual enhancement	0.117	-0.081	0.045	0.048	0.722	0.031	0.079	-0.124
Avoid impact to socio-eco	-0.243	0.142	0.052	-0.041	0.546	0.327	0.216	0.244
Provide erosion and sedimentation control plan	0.172	0.052	-0.094	0.098	0.075	0.865	0.060	-0.342
Use efficient method of erosion and sedimentation control	0.137	0.105	0.055	-0.015	0.091	0.834	0.086	-0.301
Provide 100 ft buffer	-0.099	0.098	0.049	0.028	-0.161	0.157	0.846	-0.070
Avoid impact to environment	0.044	0.090	-0.113	-0.083	0.176	0.120	0.549	0.341
Reduce urban heat island	0.240	-0.140	0.245	-0.019	0.355	-0.198	0.414	0.171
Reduce undeveloped land	0.094	0.133	-0.155	0.070	0.066	-0.440	0.019	0.953

Table 3 shows the simple results of the experts' weightings on each main and sub criterion. Those criteria had been discussed after the generated with factor loading and mean index to ensure all the weightage are reasonable in Malaysian practice in highway development. The criteria of construction management plan had the highest weightage/point from other criteria. It shows that construction management plan is the most important criteria to achieve green highway development in Malaysia. The lowest weightage/point is equipment/machinery efficiency. It is because Malaysia still used conventional machineries that use diesel or petrol. Quality management is a second important criteria in green highway development because as to achieve and maintain the green highway should have a good quality of design and construction method. Other criteria follow respectively based on their weightage/point noise mitigation, context sensitive design, erosion and sedimentation control and alignment selection. Those criteria had equal total of weightage/point. It shows that they are related to each other and had same level of important during design and construction of green highway.

Table 3 : Group and weightage of each criterion after analysis

Id	Criteria	Sub-Criteria	Element Description	Weightage/ Point
SDCA 1	Construction Management Plan	Waste Management	Provide Construction and Demolition Waste Management Plan (CWMP) during roadway construction	4
			Use efficient method of waste minimization	3
			Use efficient method of water conservation	2
			Provide Site Recycling Plan as part of the CWMP during construction	3
			Use appropriate approach for waste disposal on-site	2
		Air Pollutant	Use construction equipments that reduce emissions of localized air pollutants	2
			Dust Control	2
		Innovation	Use water tracking system	2
SDCA 2	Noise mitigation control	Technique	Use alternative construction methods with low-noise or quieter machineries	3
			Use proper noise mitigation techniques on-site	3
		Equipment	Operate stationary equipment 50 ft from noise sensitive receptor	2
SDCA 3	Equipment and machineries efficiency	Natural Source & Emission Reduction	Paving Emission Reduction	2
			Fossil Fuel Reduction	2
			Equipment Emission Reduction	2
SDCA 4	Quality management	Management Plan And Training	Provide Site Maintenance Plan	4
			Provide Quality Management System to improve construction quality	4
			Contractor Warranty	3
			Provide Environmental Training On-Site	3
SDCA 5	Context sensitive design	Design Flexibility	Design to adjust highway features using design flexibility	3
			Design to utilize visual enhancement	3
			Design to avoid impact to socio-economic resources	2
SDCA 6	Erosion and sedimentation control	Erosion & Sedimentation Plan	Provide Erosion and Sedimentation Control Plan	4
			Use efficient method of temporary erosion and sediment control	3
SDCA 7	Alignment selection	Environmental Impact Reduction	Design to provide >100 ft buffer between highway and high quality area	3
			Design to avoid impacts to environmental resources	2
			Design to reduce urban 'heat island' effect	2

5. Conclusions

As a conclusion for there are seven main factors for design and construction activities criteria for green highway development. Each factor has their own criteria which relate to each factor. All the criteria grouping in each factor base on the feedback analysis of the questionnaires survey. Thus, the criteria were dividing equally based on the experience opinion. Those main and sub criteria had been developed to achieve a green highway development in Malaysia. All the criteria had related to each other during the stage of design and construction of highway. So far there are very few studies on evaluation of green highway development all over the world but there are still lacking in infrastructure development especially highway development in tropical region. Therefore, this paper attempts to establish an evaluation model for green highway for the design and construction activities category by a scientific approach to identify the decision criteria as well as the assessment of weights for them.

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