

1st Expert Group Meeting on “Supporting the policies on green and resilient transport infrastructure along the Asian Highway Network”

AN EVALUATION OF SUSTAINABLE DESIGN AND CONSTRUCTION ACTIVITIES CRITERIA FOR GREEN HIGHWAY

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INTRODUCTION

The construction industry has given one of **the highest impacts on the environmental issues** in terms of energy usage, wastage of the products, and material used in the industry itself.

As a developing country, Malaysia needs highway development and redevelopment, but it inherently contributes to environmental impacts such as stimulation of urban sprawl, loss of open space, noise pollution, and air pollution.

Malaysia has made an ambitious commitment to **reduce** the intensity of its **carbon** emissions, notably a 40% **reduction** by 2020 and a **45% reduction** by 2030.

Therefore, an improvement of to sustain highway development is needed, as it will lead to green highway, minimal usage of fuel, and greenhouse gas reduction. Apart from that, it is necessary to have an indicator to reduce greenhouse gases during highway construction.



PROBLEM STATEMENT

Highway construction development is an energy dependency development - leads to generate greenhouse gases (GHG) directly and indirectly.

Thus, there is a need of promoting and implementing sustainability in highway construction.

One of the effective methods is sustainability assessment.

> 70 sustainability assessment but mostly focusing on building sector.

Therefore, the development of assessment tool for highway is needed and yet, there is no clear assessment of green highway construction in tropical region.

This paper aims to





OBJECTIVES

OBJECTIVE 1

To identify and establish criteria of sustainable design and construction activities for green highway development

OBJECTIVE 2

To determine weightage for each criteria of sustainable design and construction activities for green highway development

OBJECTIVE 3

To determine a score for each criteria of sustainable design and construction activities for green highway development

SCOPE OF RESEARCH

Focuses only on sustainable design and construction activities in green highways development

This research will be conducted through survey questionnaires and interview with the 143 respondents from management and technical level in 22 concessionaires' companies, consultants and contractors who are having experience in highway development.

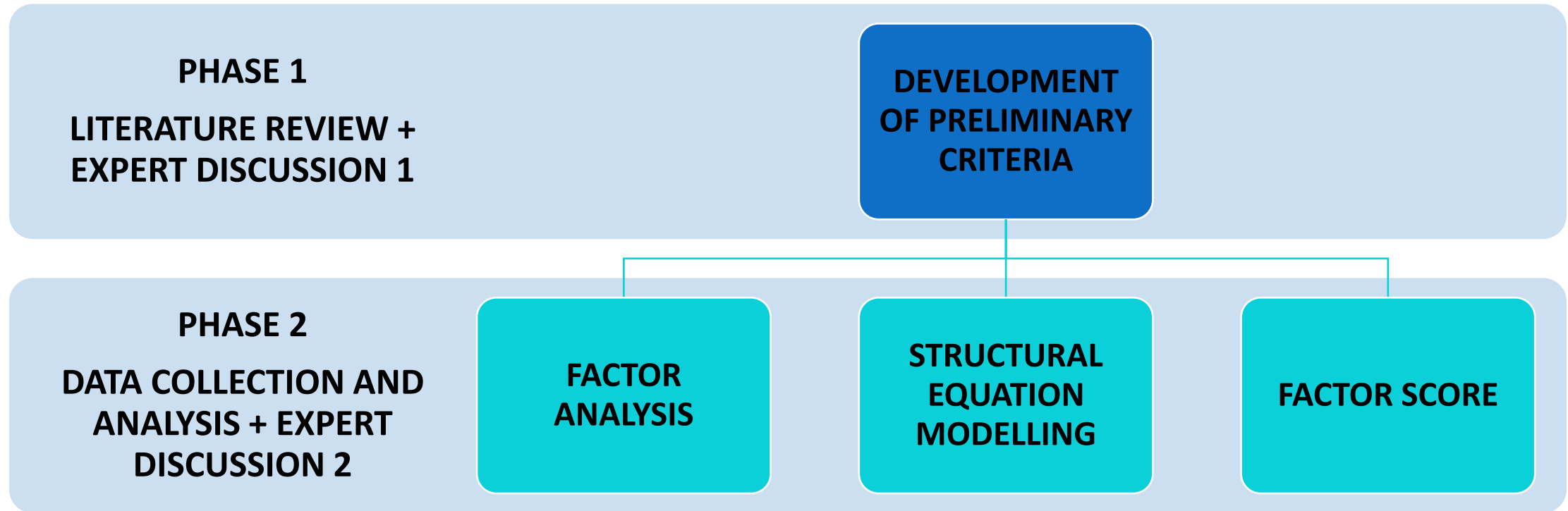
This research focuses only on three (3) states in Malaysia that had most highways development which was Kuala Lumpur, Selangor, and Johor.

01

02

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RESEARCH DESIGN



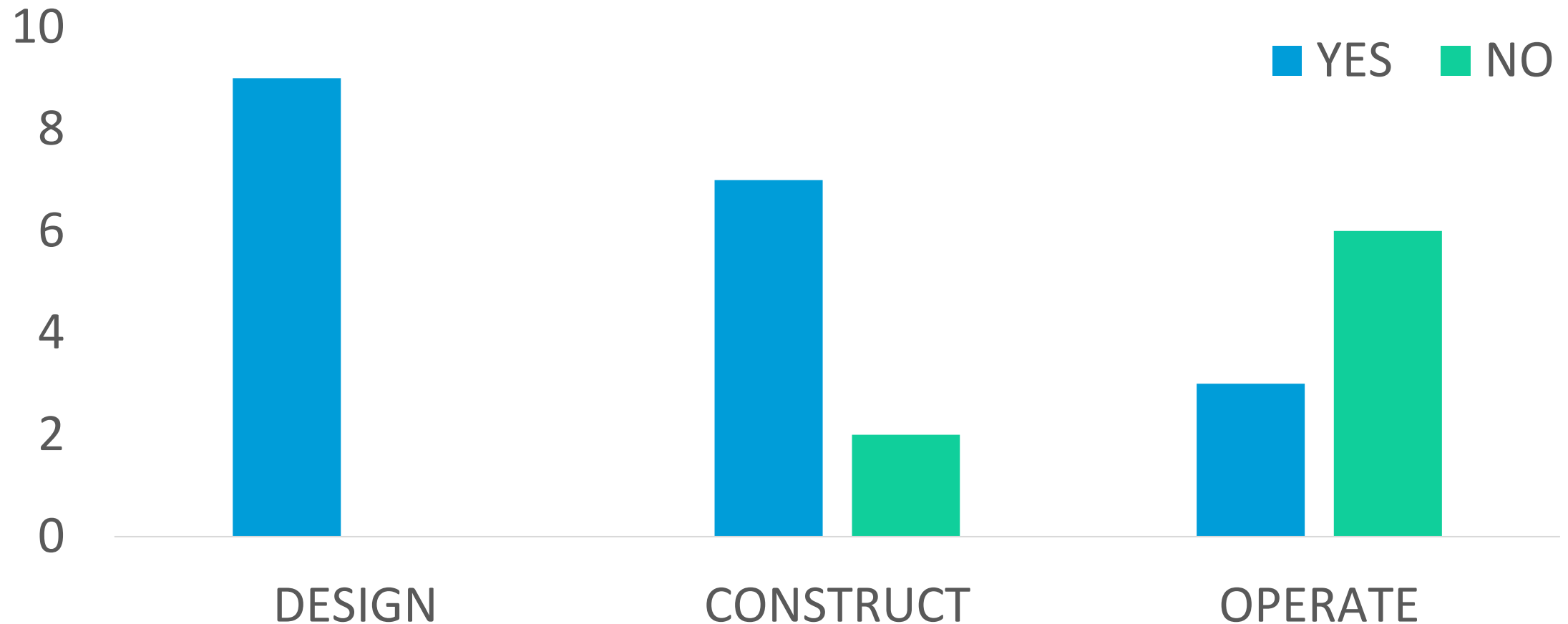


LITERATURE REVIEW

COMPARISON OF CURRENT ASSESSMENT TOOLS

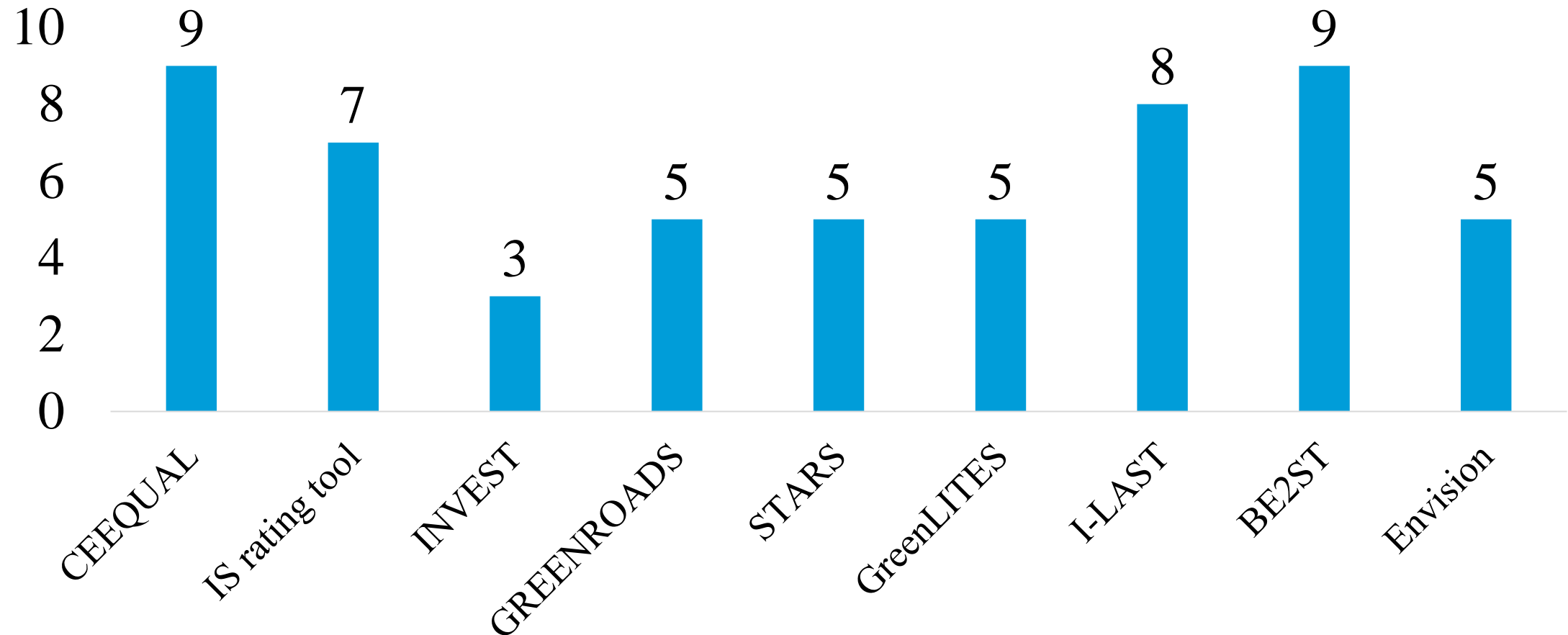
CRITERIA	CEEQUAL	Infra structure Sustain ability Rating Scheme	INVEST	Green roads	STARS	Green LITES	I-LAST	BE2ST in Highways	ENVISION
Country of origin	UK	AUSTRALIA	AUSTRALIA	USA	USA	USA	USA	USA	USA
Launch year	2011	2010	2010	2009	2011	2010	2010	2012	2012
Infrastructure / Transportation Focus	Infrastructure	Infrastructure	Transportation	Transportation	Transportation	Transportation	Transporta tion	Transporta tion	Infrastructu re
Type of system	Third-party certification	Third-party certification	Agency certification	Third-party certification	Third-party certification (to be developed)	Agency certification	Self- evaluation	Unknown	Third party
Certification levels	Pass/ Good/ Very good/ Excellent	Good/ Excellent / Leading	Bronze / Silver / Gold / Platinum	Certified / Silver / Gold / Evergreen	N/A	Certified / Silver / Gold / Evergreen	N/A	Bronze/ Silver/ Gold	Verified/ Silver Gold/ Platinum
Stage of use	Design, Construction,	Design, Construction, Operation and Maintenance	Design, Construction, Operation and Maintenance	Design, Construction, Operation and Maintenance	Design, Construction,	Design, Construction, Operation and Maintenance	Design, Constructi on,	Design, Constructi on,	Planning, design
Total points	5016	105	SP : 144 PD : 778 OM : 126	130	N/A	271	321	N/A	1000
Minimum point required	25%	24%	30%	30%	40%	15 points	N/A	50%	20%

COVERAGE OF INFRASTRUCTURE LIFE CYCLE PHASE BY SUSTAINABLE ASSESSMENT TOOLS



COMPARISON NUMBER OF CRITERIA FOR EACH ASSESSMENT TOOLS

(page 89)

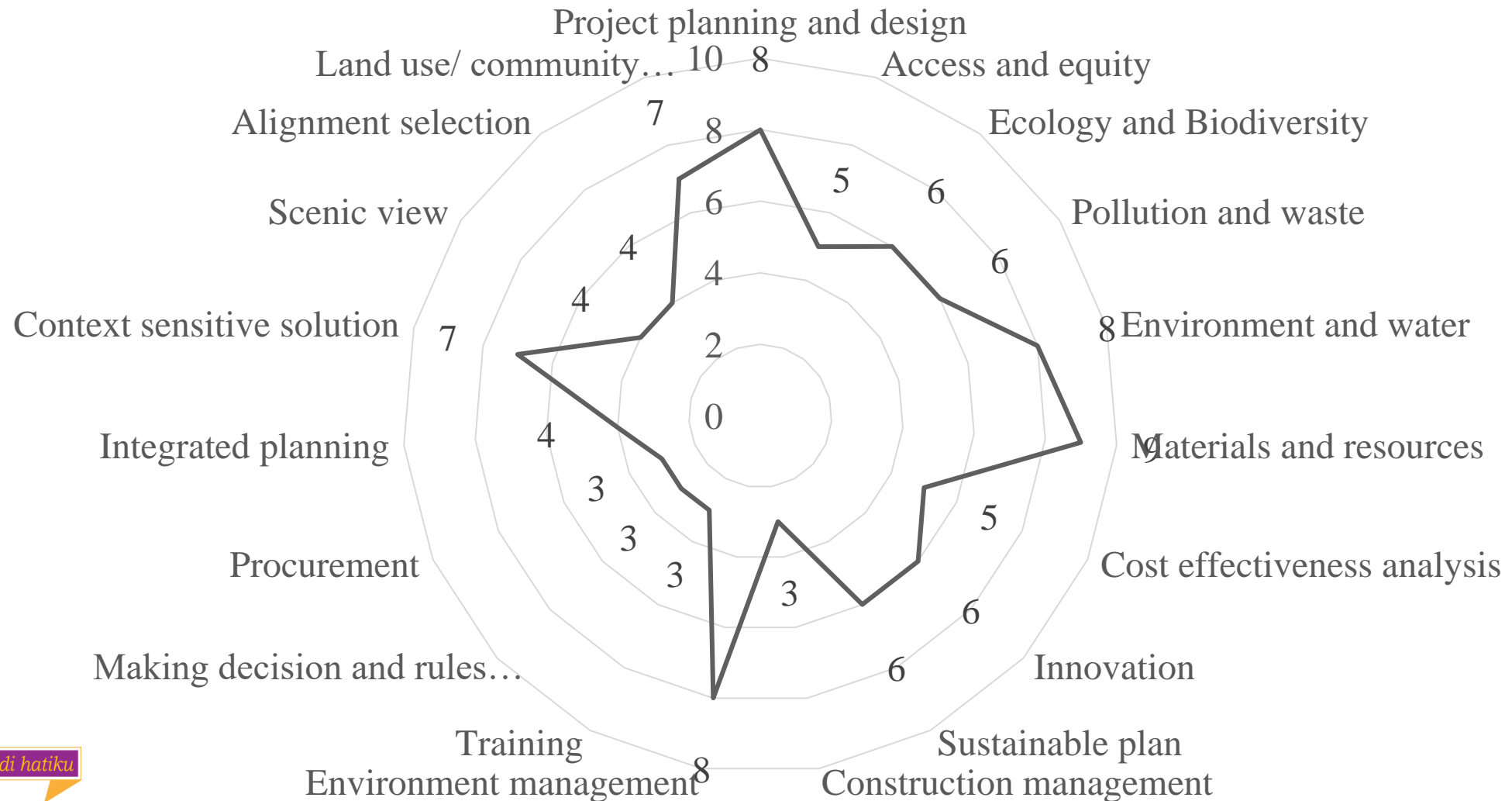


CRITERIA FOR DESIGN AND CONSTRUCTION STAGES FROM EACH GREEN ASSESSMENT TOOL



Item	Criteria	CEEQUAL	IS Rating Scheme	INVEST	GREEN ROADS	STARS	Green LITES	I-LAST	BE ² ST	ENVISION	TOTAL
1	Project planning and design	/	/	/		/	/	/	/	/	8
2	Access and equity	/	/	/	/			/			5
3	Ecology and Biodiversity	/	/	/		/		/		/	6
4	Pollution and waste	/	/	/	/				/	/	6
5	Environment and water	/	/	/	/		/	/	/	/	8
6	Materials and resources	/	/	/	/	/	/	/	/	/	9
7	Cost-effectiveness analysis		/	/	/	/			/		5
8	Innovation		/	/		/	/	/		/	6
9	Sustainable plan	/	/	/	/	/				/	6
10	Construction management	/		/	/						3
11	Environment management	/	/	/	/	/		/	/	/	8
12	Training	/		/	/						3
13	Making decision and rules and regulations		/						/	/	3
14	Procurement	/	/							/	3
15	Integrated planning			/		/		/		/	4
16	Context sensitive solution	/	/		/		/	/	/	/	7
17	Scenic view	/		/	/				/	/	4
18	Alignment selection	/	/				/	/			4
19	Land use/ community planning	/	/	/	/		/	/		/	7

CRITERIA DISTRIBUTION FOR DESIGN CONSTRUCTION STAGES FOR GREEN HIGHWAY



WEIGHTING THE CRITERIA

Questionnaires are designed to determine the weight of criteria

Principal component analysis is one of the widely used for the weighting of variables.

COMPARISON OF RANGE OF SCORE PERCENTAGES

ASSESSMENT TOOLS	PROJECT MANAGEMENT	WASTE MANAGEMENT	ENVIRONMENT & WATER	ECOLOGY & BIODIVERSITY	MATERIALS	CONSTRUCTION ACTIVITIES	PEOPLE AND COMMUNITY	INNOVATION	COSTING	ENERGY	TRANSPORTATION
CEEQUAL	11.43%	8.15%	15.11%	9.15%	9.34%	-	29.53%	-	-	9.74%	7.55%
IS RATING SCHEME (1.0)	19.52%	23.33%	-	10%	23.33%	-	23.81%	-	-	-	-
INVEST	43%	-	-	-	-	58%	-	-	-	-	-
GREEN ROADS	-	-	18%	-	36%	12%	25%	8%	-	-	-
STARS	-	-	-	-	-	-	-	-	-	-	-
GREEN LITES	-	27%	9%	-	23%	-	-	8%	-	33%	-
I-LAST	19%	-	37%	-	18%	-	7%	1%	-	-	18%
BE2ST	11.1%	33.3%	11.1%	-	-	-	11.1%	-	22.2%	11.1%	-
ENVISION	13%	-	8%	32%	29%	-	18%	-	-	-	-
RANGE OF SCORE %	10 – 20%	8-34%	8-37%	10-32%	9-36%	12-58%	7-30%	0-8%	0-22.2%	9-33%	7-18%

DEVELOPMENT OF 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

DEMOGRAPHIC ANALYSIS



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 years working experience and they were very experienced with highway development.

FACTOR ANALYSIS

A factor analysis was initially conducted on 29 items with oblique rotation (promax). However, three items were removed due to 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

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.

8 factors had eigenvalues over Kaiser's criterion of 1 and explained 68% of the variance

FACTOR LOADING

Main criteria	Element	Factor Loading
Construction Management Plan	Provide Construction and Demolition Waste Management Plan (CWMP) during roadway construction	0.97
	Use an efficient method of waste minimization	0.73
	Use an efficient method of water conservation	0.64
	Provide Site Recycling Plan as part of the CWMP during construction	0.64
	Use construction equipment that reduces emissions of localized air pollutants	0.60
	Dust Control	0.54
	Use a water tracking system	0.52
	Use appropriate approach for waste disposal on-site	0.43
Noise mitigation control	Use alternative construction methods with low-noise or quieter machinery	0.89
	Use proper noise mitigation techniques on-site	0.79
	Operate stationary equipment 50 ft from noise sensitive receptor	0.71
Equipment and machinery efficiency	Paving Emission Reduction	0.83
	Fossil Fuel Reduction	0.81
	Equipment Emission Reduction	0.62
Quality management	Provide Site Maintenance Plan	0.81
	Provide a Quality Management System to improve construction quality	0.72
	Contractor Warranty	0.69
	Provide Environmental Training On-Site	0.68
Context sensitive design	Design to adjust highway features using design flexibility	0.78
	Design to utilize visual enhancement	0.72
	Design to avoid impact on socio-economic resources	0.55
Erosion and sedimentation control	Provide Erosion and Sedimentation Control Plan	0.87
	Use an efficient method of temporary erosion and sediment control	0.83
Alignment selection	Design to provide >100 ft buffer between the highway and high-quality area	0.85
	Design to avoid impacts to environmental resources	0.55
	Design to reduce urban 'heat island' effect	0.41

MAIN CRITERIA

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

FACTOR ANALYSIS, FACTOR SCORE & SEM (AMOS)

FACTOR ANALYSIS & FACTOR SCORE

All variables in the criteria were mixed between sustainable designs and construction activities.

There are 7 main factors for the criteria of design and construction activities for green highway development which are related to each factor.

The FACTOR SCORE also had been developed during factor analysis process.

However, the criteria also were divided equally based on the opinion from the experience during expert discussion 2.

SEM (AMOS)

The sustainable design and construction activities assessment tool were positively supported by the analysis.

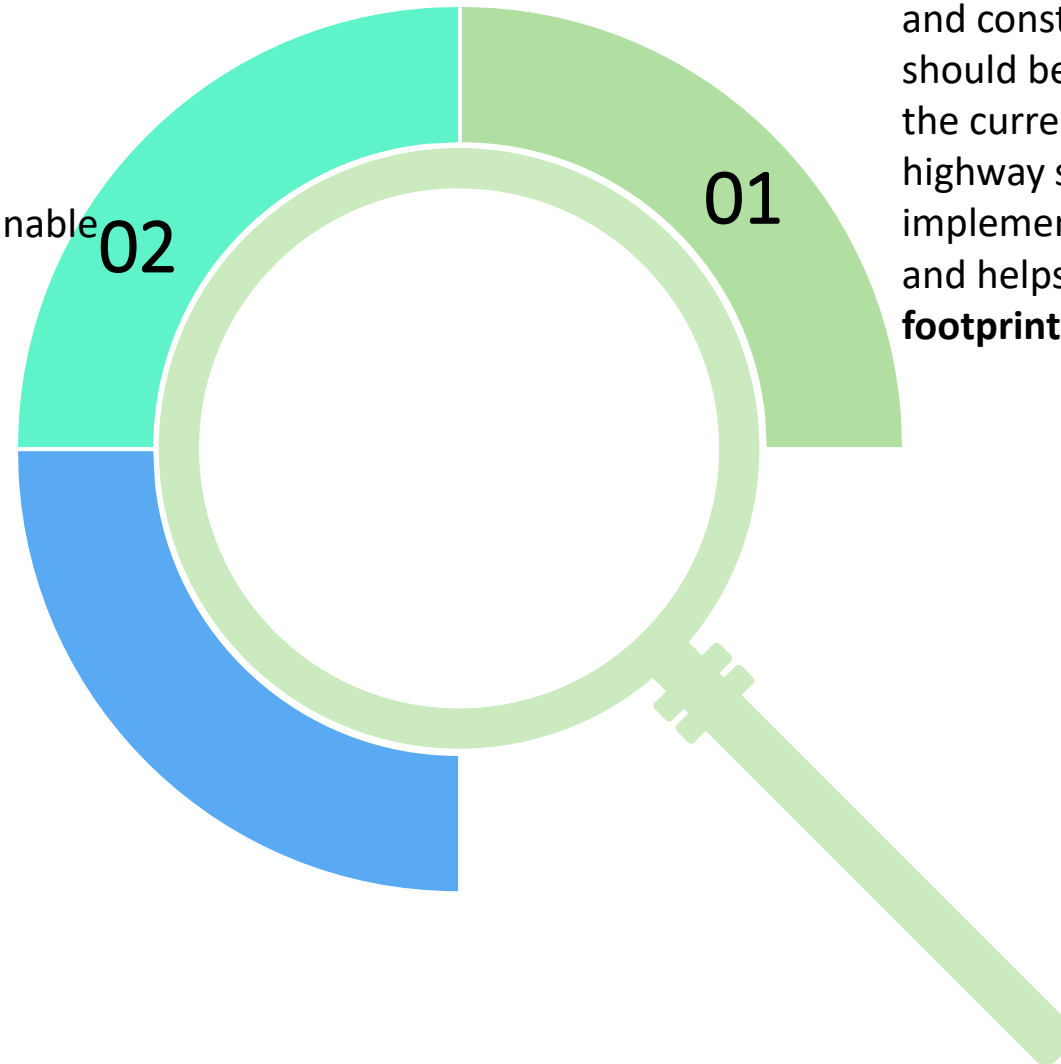
All the main criteria and sub criteria were positively related to one another.

Therefore, it can be summarized that the assessment tool of sustainable design and construction activities is confirmed.

It can be used as a scorecard for the assessment tool in green highway.

CONTRIBUTION TO THE BODY OF KNOWLEDGE

This research contributes to the recent Construction Industry Transformation Programme (CITP) 2016-2020 agenda to **promote high amenability to the environmental sustainability ratings** and practices in achieving a low carbon, sustainable building, and infrastructure hub.



The assessment tool for sustainable design and construction activities for green highway should be used as a **fundamental approach** in the current system by encouraging the highway stakeholders to improve the implementation of the sustainable elements and helps **to reduce the emission of carbon footprint during the construction stages**.

THANK YOU

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