

Toward Sustainability: Green Road Construction in Indonesia

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Abstract—Road construction projects can affect directly to the degradation of the environment for causing emission, pollution, and congestion. Green road rating is the tool to measure the performance of green practices and the level of greenness on road construction projects. However, the implementation of the tool to identify how far the green concepts applied in road construction projects still lack in Indonesia. Thus, this research aims to review the extent of the implementation of green road tool in its contribution to the achievement of sustainability goals. The objectives of this research are to determine the level of the greenness of roads by clustering 12 roads and to identify the performance of each main category and subcategory related to the areas of success and the areas in need of improvement based on points obtained. Two methods used in this research are the descriptive method and cluster analysis. The research shows that the level of the greenness of 12 roads is a good adoption of green practices, in which 3 roads are awarded gold stars, and 9 roads are awarded silver stars. In addition, main categories of environment, construction, and material are more implemented than transportation and pavement among the road clusters. While the performance of subcategories namely ecological protection, economic and accessibility are more successful than resource efficiency, safety and environmental quality related to pavement and construction activities. Hence, the implementation of the green road in Indonesia has contributed more to the achievement of natural goals than human goals. Ultimately, policy recommendation is needed for improvement.

Keywords: *green road implementation, green road rating, sustainability goals*

I. INTRODUCTION

Road construction and transportation sectors contribute considerably to the degradation of the environment as they consume a large number of materials and energy and produce a massive amount of waste [1] and create threats such as emission, pollution, congestion and financial scarcity [2].

Road projects produce greenhouse gas (GHG) emissions during the whole life cycle of their construction phases. GHG emissions on the construction stage are generated from the materials and equipment used. GHG emissions from primary road supply cause around 80% due to material consuming [3]. Roads constructed with the characteristic of a 1kilometer length and typical 2-lane roads with flexible pavement spend 6 TJ (tera joule) of energy [4]. Therefore, a sustainability approach is needed to be adopted

in the whole life cycle on construction industries involving its design, construction, and remodeling [5].

Many aspects of sustainability are considered to be implemented on highway development but to measure the level of greenness is difficult without an assessment tool [4]. As a consequence, the implementation of the green road rating system in some countries is becoming an important issue. To deal with the issue of sustainability in the road construction project, the green road rating system can provide a valuable way and a holistic tool through a quantitative approach that could guide for decision-making [5].

In Indonesia, the government is more concerned about integrating the concepts of sustainability in construction industries since the issue of global warming and climate change have become important issues. These international concerns become pressure for Indonesia to adopt the principles of sustainable practices into its construction industries. Global demands, The Rio + 20 Conference in 2012 and the Pittsburgh Summit in 2009 become a basis to commit in advancing of sustainable development [6] and to reduce greenhouse gas emissions by 26% - 41 %, including gas emissions generated from energy and transportation by 3.8%, and industry by 1.8% [7].

The Presidential Regulation of the Republic of Indonesia Number 61 of 2011 on the National Action Plan to reduce greenhouse gas emission was released to meet the GHG emission reduction goal by 2020 [7]. Furthermore, the Ministry of Public Works in Indonesia has integrated the green practices on the road construction industry by establishing related law and regulations under the Law Number 13/PRT/M/2015.

Such law is fundamental as the development of roads at the national, provincial and district levels in Indonesia has been increasing from 523.974 kilometers in 2015 to 539.415 kilometers in 2017 [8]. The number of toll roads constructed has also increased significantly. The length was targeted to reach 1.852 kilometers of total toll roads in 2019 [9].

The green rating tool can be used to measure the performance of indicators on determining the level of greenness, to measure sustainable practices and to promote decision-making in the road construction industry [10], [11], [12]. Yet, other research stated that the implementation of green constructions on highway projects faced many

challenges related to materials, equipment, codes and standards, financial issues [13], regulations, and culture [14].

Through the case study using data from Pusjatan, a Research and Development Road Center Agency in Indonesia [15], this research aims to review the extent of the implementation of green road rating tool in its contribution to the achievement of sustainability goals. The objectives of this research are to determine the level of the greenness of roads by clustering 12 roads and to identify the performance of each main category and subcategory related to the areas of success and the areas in need of improvement based on points obtained.

II. LITERATURE REVIEW

A. Green Road in Sustainability

Green road is the umbrella concept for research and development of sustainable road construction projects [16]. Green road aspects focus on, namely: (1) watershed and water management, (2) energy and emission reduction, (3) recycled, reusable and renewable materials, (4) conservation and ecosystem management, and (5) social benefits [17].

Green road contributes to the roadway systems' sustainability since its object and criteria can improve "natural laws" and "human values" [18]. Natural goals are to protect and enhance the quality of the ecosystem and environment and resource efficiency, whereas human goals aim to improve the quality of social life or no-energy benefits [17].

The performance of indicator or category can be measured from energy efficiency, ecological protection, and environmental quality in the scope of natural laws, while the performance of human values consists of accessibility, safety and mobility, and economy. Hence, to achieve these goals, the criteria of sustainability goals targeted are established (see Fig.1) [18].

B. Green Highway Rating System

Green highway is the integration of sustainable practices on the highway development that promote the concepts of

the environment in every phase of a project [10]. The rating system tries to measure the performance of the decision or plan on transport by providing credits for sustainable practices [12]. The credits refer to points to measure sustainable practices or serve as a method to measure sustainable design and construction on a roadway project [16].

Researchers argue that such quantification is useful for describing attributes that contribute to sustainability on the roadway, providing a tool for measuring sustainability on the road project, communicating project attributes to stakeholders, and managing and advancing sustainable roadways [16].

Some countries including Malaysia, Indonesia, and South Korea have developed their criteria of green road tools by adopting rating tools, such as Green Road, Green Lites and I-LAST, respectively [19], [12], [20]. INVEST and BES² In Highway rating tools are included to assess the transport sector [20]. TABLE I for the list of 5 rating systems.

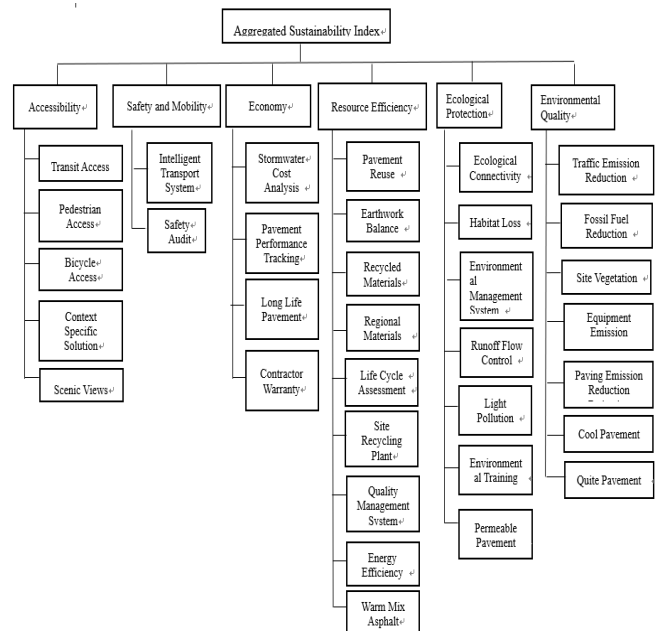


Fig. 1. The relations of sustainability criteria and goals.

TABLE I. LIST OF RATING SYSTEMS

	Green Road USA	INVEST	Green Lites	I-Last	Green Road Indonesia
Development year/ Origin Country/ Developers	2011/USA University of Washington	2012/USA Federal Highway Administration	2008/USA New York State Department of Transportation	2010/USA Illinois Department of Transport	2013/Indonesia Center of Road and Bridge Development (PUSJATAN)
Applicable to Phase of Project	Project Development	Planning Project Development Operation Maintenance	Planning Design Construction Operation Maintenance	Project Development	Project Development
Attributes Considered	Water, Run of Quantity, Aquatic Habitat, Air, Light, Noise, Materials, Local Materials,		Water, Run of Quantity, Light, Noise, Carbon, Materials, Local of Materials, Recycling, Waste,	Water, runoff Quantity, Water Quantity, Light, Noise, Carbon, Materials, Energy, Electricity, Community,	Water, Run of Quantity, Water Quality, Aquatic Habitat, Air, Light, Noise, Carbon, Materials, Local

	Green Road USA	INVEST	Green Lites	I-Last	Green Road Indonesia
	Recycling, Waste, Energy, Ecology, Other modes, Lifecycle Cost		Energy, Electricity, Fuel, Ecology, and Community.		Materials, Recycling, Waste, Energy, Fuel, Ecology, Community, Lifecycle Cost, other modes.
Total Points And Minimum Points	118 / 16	System Planning, 160 Project Development, 85/117	278/75	233/30	100/20
Scale of Points	1 - 5	1-3	1-3		0-6
Levels of Award	Certified Award < 32 Bronze Award 32-42 Silver Award 45-53 Gold Award 54-63 Evergreen>64	None < 30% Bronze Award ≥ 30% Silver Award ≥ 40% Gold Award ≥ 50% Platinum Award ≥ 60%	Green LITES Certificate 15 – 29 Green LITES Silver 30 – 44 Green LITES Gold 45 – 59 Green LITES Evergreen (60 & up)	N/A	Certified Award <20 Bronze Award 20-30 Silver Award 30-45 Gold Award > 45
Percentage of Categories	Materials and Pavement Technology (40) Environmental and Water (19%) Design and Construction (13%) Access and Equity (28%)	Materials and Pavement Technology (10%) Environmental and Water (2%) Design and Construction (8%) Access and Equity (73%) Energy Efficiency (7%)	Materials and Pavement Technology (25%) Environmental and Water (8%) Design and Construction (30%) Access and Equity (2%) Energy Efficiency (35%)	Materials and Pavement Technology (18%) Environmental and Water (37%) Design and Construction (20%) Access and Equity (18%) Energy Efficiency (7%)	Materials and Pavement Technology (20) Environmental and Water (27%) Design and Construction (19%) Access and Equity (14%) Energy Efficiency (20%) -

Source: [16, 6, 21, 22, 23, 24].

C. Indonesia Green Road

Green road in Indonesia is a voluntary evaluation of road construction that seeks to apply green criteria at the design and construction phase to achieve road sustainability [6]. The development of green road criteria was adopted from

international sustainable rating tools, such as Green Road, INVEST and ILAST that are focused on the project development on design and construction [6]. The category is divided into 5 areas and the main requirements that must be fulfilled are road construction plan, life cycle cost analysis and environmental documents shown in TABLE II.

TABLE II. SUMMARY OF GREEN ROAD IN INDONESIA [13]

Main Category	Sub-Category	Total Credit for each category	Sustainability Dimension	Supporting Regulation of Indonesia Public Works Agency
Environmental and Water	1. Environmental and Management System and Innovation 2. Drainage arrangement 3. Flood Control 4. Dust Reduction 5. Noise reduction 6. Planting Trees and Plants 7. Certified ISO Quality Management and Environmental Management 8. Environmental and ecosystem protection 9. Light Setting	27	1. Environmental 2. Environmental 3. Economic 4. Environmental 5. Social 6. Environment 7. Economic 8. Environmental 9. Environmental	Environmental Dimension - Drainage guidelines - Procedures of rainfall catchment well - Guidance of plantation for road network system
Transportation and Society	1. Provision of access and pedestrian 2. Provision of access and cyclist 3. Provision of access to public transport 4. Provision of design geometric and facilities 5. Safety Audit 6. Community Participation 7. Provide facility for a scenic view 8. Provide Ornament and Landscape	14	1. Economic 2. Economic 3. Economic 4. Economic 5. Social 6. Social 7. Economic 8. Economic	Social Dimension - Pedestrian and Cyclist Technical Guidelines - SMK3 Construction, - Safety Audit Guidelines - Noise mitigation guidelines
Construction Activity	1. Ownership of ISO Certificate quality management and environmental management. 2. Reuse old materials at the project site 3. Fossil fuel reduction from outside of construction work. 4. Equipment emission reduction at the project	19	1. Economic 2. Economic 3. Environmental 4. Environmental 5. Environmental 6. Environmental	Economic Dimension - Planning and road geometric guidelines - Road Pavement Design guidelines

Main Category	Sub-Category	Total Credit for each category	Sustainability Dimension	Supporting Regulation of Indonesia Public Works Agency
	site 5. Paving emission reduction 6. Regulation of water use at the project site 7. Contractor warranty 8. Use of renewable energy 9. Carbon needs 10. Coordination between planning and construction.		7. Economic 8. Environmental 9. Environmental 10. Social	- Quality Management Guidelines - Environmental System management guidelines.
Materials and Natural Resources	1. Reuse materials 2. Earthwork Balance 3. Recycling materials 4. Use of local material 5. Light Efficiency 6. Use excess material outside the project site	20	1. Environmental 2. Economic 3. Economic 4. Economic 5. Environment 6. Economic	
Pavement Technology	1. Long-pavement design 2. Permeable Pavement 3. Warm Mix asphalt 4. Cold Pavement 5. Quite pavement	20	1. Economic 2. Environmental 3. Environmental 4. Environmental 5. Environmental	
	Total Point	100		

III. METHODOLOGY

This research consists of 5 steps, which started from the introduction, literature review, methodology, result and discussion, and conclusion. The data used is the secondary data from Pusjatan [6, 15]. There are 12 roads reviewed. Quantitative and qualitative method is used in this study by applying cluster analysis and descriptive study.

The cluster analysis is used to find the similarities in the level of greenness and differences of achievement in each category of green road. The goals of sustainability on each subcategory are examined by descriptive research.

IV. RESULTS AND DISCUSSION

A. Clustering the Level of Greenness

TABLE III shows the clusters of 12 roads that have similarities of achievement on average total points. Road clusters are divided into three clusters. The first cluster is Kelok Sembilan, Tol Mandara, and Dewa Ruci; the second cluster is Flyover Bukit Tinggi, Ibnu Kamojang, Semarang Toll Road, Ibnu Kamojang, Kelok Sembilan, Tol Mandara, Dewa Ruci, Braga Street, Kartini Gajah Street, Tayan Bridge Street, and Gerung Street, and; the third cluster is Karang Gadong Street.

TABLE III. ROAD CLUSTERING

Case	Cluster Membership	Squared Euclidean Distance											
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1)	1	.000	5.087	5.785	5.661	5.565	6.809	19.841	6.354	13.676	6.360	7.401	8.018
(2)	1	5.087	.000	2.589	5.203	13.816	2.980	24.638	8.939	13.816	11.768	9.116	14.522
(3)	1	5.785	2.589	.000	7.932	12.099	7.066	33.938	11.627	21.096	16.740	14.161	16.815
(4)	2	5.661	5.203	7.932	.000	4.788	4.118	19.791	2.852	7.415	4.661	3.069	3.024
(5)	2	5.565	13.816	12.099	4.788	.000	12.577	23.721	6.813	12.527	7.680	7.926	2.352
(6)	2	6.809	2.980	7.066	4.118	12.577	.000	13.077	7.336	8.470	9.178	3.088	11.131
(7)	3	19.841	24.638	33.938	19.791	23.721	13.077	.000	23.444	8.622	18.448	8.896	19.900
(8)	2	6.354	8.939	11.627	2.852	6.813	7.336	23.444	.000	15.831	1.306	4.037	3.401
(9)	2	13.676	13.816	21.096	7.415	12.527	8.470	8.622	15.831	.000	13.820	6.138	9.931
(10)	2	6.360	11.768	16.740	4.661	7.680	9.178	18.448	1.306	13.820	.000	3.733	3.167
(11)	2	7.401	9.116	14.161	3.069	7.926	3.088	8.896	4.037	6.138	3.733	.000	4.309
(12)	2	8.018	14.522	16.815	3.024	2.352	11.131	19.900	3.401	9.931	3.167	4.309	.000

Remarks :

- | | |
|---------------------------|----------------------------|
| (1) Kelok Sembilan | (7) Road of Karang Gadong |
| (2) Underpass Dewa | (8) Road of Braga |
| (3) Tol of Mandara | (9) Road of Kartini Gadjah |
| (4) Flyover Bukit Tinggi | (10) Bridge of Tayan |
| (5) Road of Ibnu Kamojang | (11) Tol of Bekasi |
| (6) Tol Semarang Solo | (12) Road of Gerung |

All the road clusters have indicated a good adoption of green practices. Based on the Indonesia Green Rating System (see Fig. 2), the level of greenness in the first cluster

is better than the second and third clusters. The first cluster is awarded gold stars, while the second and the third cluster are awarded silver stars. The main differences between the

silver and gold awards on the indication of the level of greenness are related to the implementation of innovation and technology.

Even though all clusters have implemented the 5 main categories required, the first cluster is better in its implementation on innovation and technology than the second and the third cluster. The first cluster has implemented a long pavement design which means that its roads' plans and designs consider the achievement of economic efficiency through minimizing the lifecycle cost of infrastructure.

The achievement of the level of the greenness of road depends on the 5 categories implemented (see Fig. 3). The category implemented is various among the clusters. The first cluster has the highest point implemented in three categories, namely; environment, transportation, and pavement. Then, this point is followed by the third cluster on the construction and material category. The second cluster has the least points of all categories.

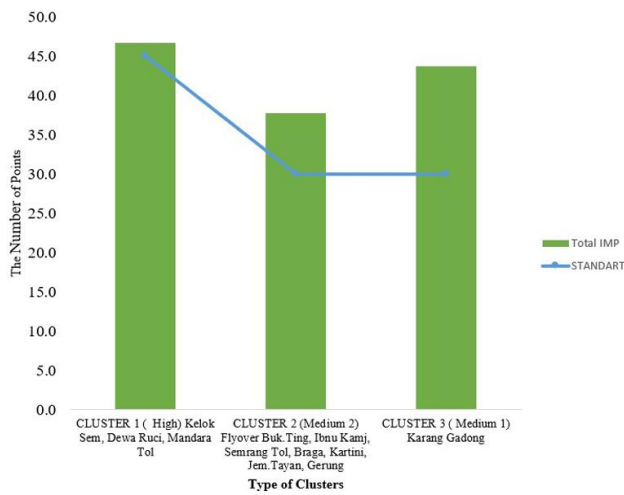


Fig. 2. Green road awards based on the road clusters.

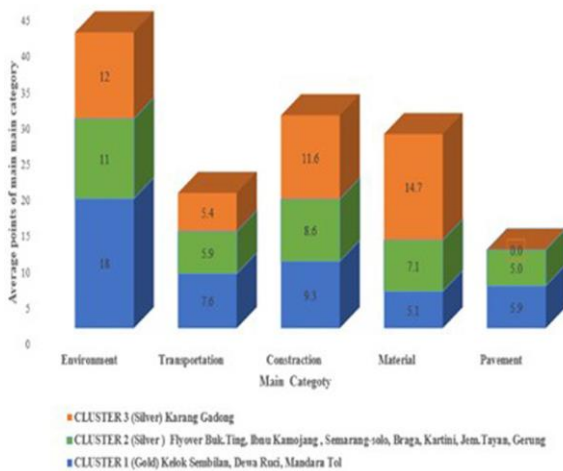


Fig. 3. Road cluster for each main category.

The majority implementation in some categories has been influenced by the type of road working project and land use of road areas. The first cluster almost has the same typical road working project on the pavement, bridge and drainage, and land use in the areas of ecological protection such as protection forest and the coastal regions. While, the second cluster is more dominant on the scope of road work projects related the provision of accessibility such as for pedestrians, light setting and planting trees, as well as land use in the commercial and residential areas.

B. Green Road Goals in Sustainability

The achievement of goals on the green road is influenced by the performance of the subcategory implemented. As seen in Fig. 4 and TABLE IV, the high achievement of goals in the ecological protection and economy is supported by the high implementation of performance related to the protection of ecological system, land, and water bodies in the environment as well as to reach economic efficiency in construction activities.

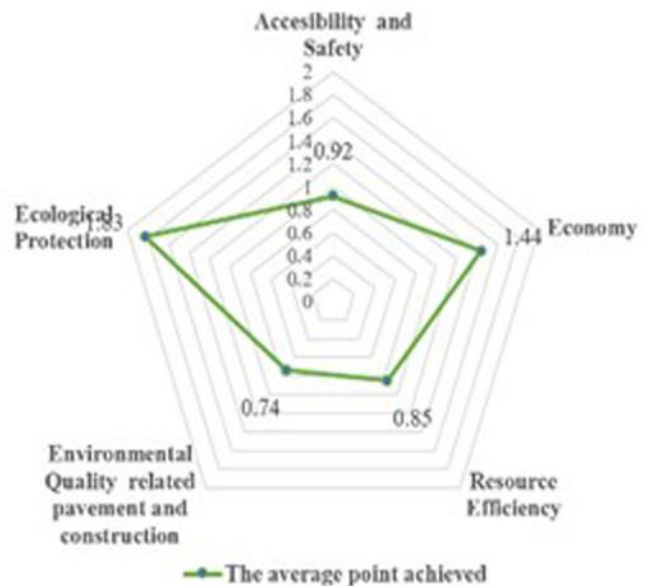


Fig. 4. Green road achievement in sustainability.

The lowest implemented of subcategory is in the environmental quality related pavement, construction and safety due to many indicators that cannot be conducted. Thus, to reach maximum goals in the area of natural value, environmental quality related to the performance of pavement and construction activities need to be advanced in the implementation.

Whereas, the human value related to the performance of safety needs to be improved in the areas of planning. The achievement on natural goals is supported by more availability of guidelines on the environment, transportation, and construction rather than on material and pavement technology.

TABLE IV. THE RANGE OF ROAD IMPLEMENTATION

Main Category	The range of road in implementing the subcategory			
	High (12-9 Road)	Medium (8-5 Road)	Low (4-1 Road)	No Impelemented
Environment	Environmental Management System, Drainage System, Planting Trees and Plans, Dust Reduction, Light Setting, Flood control	Noise Reduction, Environmental and Ecosystem Protection, ISO Quality Management		
Transportation	Geometric and facilities, Community Participation, Access and Pedestrian, Provide Scenic View, Ornament and Landscape	Safety Audit and Access to public transport	Pedestrian Path and Cyclist	
Construction	Ownership and Quality Management, Contractor warranty, Cordination and Planning Construction	Reused old pavement material, Fuel Reduction	Local Material Use, Regulation of Water Use, Renewable Energy, Equipment Emission Reduction	Carbon Needs
Material	Local Material and Regional Material	Efficiency Light Setting	Reuse old Material, Earth work balace, recycled materials	
Pavement		Long Pavement Design	Cool pavement, pavement with noise reduction	Permeable Pavement, Warm Mix Asphalt

V. CONCLUSIONS

Indonesia road project has shown a good adoption of green practices by achieving the second standard of the green rating award. The goals to protect environment and ecological system have been achieved, rather than to get to improve the human value. So, it is need to be some to create some polices or strategies such as regulation related of standard of materials and planning related to road design based on the local context.

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