An Assessment of Green Rural Road Criteria and Elements for My Green Rural Road Index: A Case Study in Pengerang, Johor

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Abstract. The rural road networks were built to connect the rural people to the town area or to other destination required by the local residents. Normally the rural roads will be developed to connect or increase the socio-economic opportunity in rural area. The green road is one of the key areas that can be look into to create the sustainable concept based on three key aspects namely social, environmental and economic factors. The main focus of the economy aspect is to increase the profits using more efficient resources, especially materials, improving the quality of life by meeting the national needs of social aspects and protecting the environment from the effects of CO^2 emissions and efficient use of natural resources for environmental aspects. Therefore, it is important that stakeholders include sustainability criteria in their projects. The application of a sustainable concept on the road can be assessed by the green road evaluation tool. Therefore, the main aim of this study is to build tools to evaluate and declare green rural roads in Malaysia. The data for this study were gathered through group discussions with road construction experts and distributed questionnaires to identify sustainability factors. Then the data were analysed by factor analysis method using SPSS software. Based on the result, there are five main sustainable criteria: Sustainable Design and Construction, Social and Safety, Energy Efficiency, Environmental and Water Management and Materials and Technology that are included in the development of the green road qualification system. The analysis indicates that the social and safety become the prime criteria among other criteria.

1. Introduction

Rural road is defined as low traffic volume roads located in forested settings that serve residential and recreational purpose [1]. They may have been constructed to relatively low standards with a limited budget and with one or two lanes wide using natural, gravel and other surfacing. Nowadays, green rural road has become one of the favoured methods in road construction as it can improve quality of living and lessen the impact to environment. Green road is the new idea of road construction to provide a sustainable road in terms of social, economic and environmental factors. It is designed and constructed with highest level of sustainability compared to the current ordinary road. It is a collection

of sustainability best practices that apply to roadway design and construction throughout the stages of planning, design, construction and service life [2]. This kind of project play an essential role in a nation's social and economic as it uses of low impact of development tools, recycle materials and local resources and mitigate the negative impacts on the surroundings to a minimum level through green concepts and sustainable practices. The criteria of green roads are Sustainable Design and Construction, Material and Resources, Environmental and Water Management, Energy Efficiency and Social and Safety [4]. Green rural road needs more consideration, alertness and application of all the parties like the route concessions, the drivers, and the most vital is that the authority which can enhance the property of the green conception of road style which will be sustained at the life cycle basis [3].

Currently in Malaysia, the guidelines for green rural road are not yet available. Thus, this study is looking at the development of My Green Rural Road Index with the purpose of addressing the sustainability elements specifically for green rural road in Malaysia. A proper guidelines and index will help to reduce the impacts of greenhouse effect, air pollution, noise pollution and water pollution. At the same time, it will increase the road safety and efficiency of road networks thus plays an important role in stimulating socioeconomic development for rural communities. Through better road access, rural development can be achieved which can stimulate rural communities' economy, increase well-being and self-realization and also creating changes among rural community from the normal means of their living to an exceedingly progressive way of living [5]. Despite the benefits of rural access, rural road however associated with several environmental impacts, in California for example, rural road has been identified as a major source of sediment production in watersheds. Thus, in order to ensure the rural road development is achieved and at the same time lessen the impact of environmental through transportation facilities, green rural road should be taken into consideration.

1.1. Green Rural Road Criteria

Green Rural Road criteria are very important for the green rural road index development. The factor analysis is based on the green criteria and elements. The SPSS Software was used to analysed the best criteria for rural road index development. Every criterion has different perspective and characteristics. The main criteria will decide the primary construction work for rural road development. The criteria are listed based on Adzar et al. [6], Abd Rashid et al. [7] and Adzar et al. [8].

The first criteria which is sustainable design and construction activities can be one of the criteria that can minimize the impacts of roads to the environment especially for plants and wildlife. The impact can be reduced by better design, construction, management of roads and other facilities [9]. The concept of sustainable design and construction already present in building construction industry but in road construction industry has just started to adopt initiatives that promote environmentally friendly. Sustainability initiatives in this arena also attempt to consider economic concerns that arrive from utilizing new materials, and construction practices [10] [11].

As for the second criteria the energy efficiency means using less energy to perform anything by eliminating energy waste. Energy efficiency brings many benefits such as reducing greenhouse gas emissions, reducing demand for energy imports and lowering our cost on household. Renewable energy technologies help to improve energy efficiency in every sector of economy in construction, transportation and buildings [12].

The third criteria is environmental and water management. One of the numerous aspects of the management are the safety of the surroundings. The green road is more on the environmentally friendly. Minimizing of cutting slope and also the preservation of vegetative downhill could be a wastage of the precious mass and it will cause a harm to the vegetative cover. Instead, having a correct cut and mill technique of mass levelling that's employed in the green road approach, the excavated materials are then used for fill on the depression facet by constructing a toe wall [13]. Water management is incredibly a lot of necessary within the rural mountain roads. Green road approach provides a good water management to improve the water quality. Besides, the slope is containing more water which can cause landslides or erosion. A better water drainage system must be provided to stop the disaster.

Based on forth criteria, the construction of the green road is the best way for surroundings because the idea can reduce the environmental impact. Green road concept is the best idea to protect the mountain slope and minimize the danger of landslide and erosion

Besides, the contractors should use best techniques in construction to minimize the carbon emission. The environment approach is like using the dozers, excavators and also the different significant equipment which may consume less quantity of the fuels for construction works and this will reduce the emission of the greenhouse gases. The development strategies are environmentally friendly because it approaches the uses of the labour-intensive methods that leads to virtually zero greenhouse emission throughout the construction of the road.

2. Background

In this study, Pengerang, Johor has been chosen as research area. Figure 1 shows the study area to conduct the questionnaire survey. The study area covered overall Pengerang such as Bandar Penawar, Kota Tinggi, Desaru and JKR Pengerang. Pengerang is well known for Malaysia's mega project named Pengerang Integrated Petroleum Complex (PIPC) which is sited in the area. The project was announced in 2011 and Pengerang was chosen for Malaysia's national project due to its strategic location. It offers access to exist major international shipping lanes. The Pengerang Integrated Petroleum Complex (PIPC) is one big step in creating value to the downstream oil and gas value chain in Johor. In less than 2 years, the area become more accessible via new Senai-Desaru Highway which has shortened the travel time to the area by an hour compared to over two hours previously via small road from Kota Tinggi. Development of rural road network in Pengerang, Johor plays an important role in stimulating development. A major portion of Pengerang, Johor population lives in rural areas, sixty percent of the population board rural Johor. In Pengerang there are several villages situated in several piece of ground condition e.g., plains, hilly and, swamp and lots of additional. The green road index based on several criteria and elements has been assessed.

My green rural road index is a research that aimed to produce valuable benefits to the environment by integrates transportation functionality and ecological requirements. It can be defined as a roadway design which is based on a relatively new concept of roadway design in which environmental approach is used throughout the planning, design, and construction stages. Green road will benefit not only to the transportation infrastructure, but towards ecosystem, urban growth, public health, and surrounding communities as well [14]. The main objective of this study is to identify the criteria and elements for the development of My Green Rural Road Index and to categorized the identified element into specified criteria. These were achieved through the method explained below.

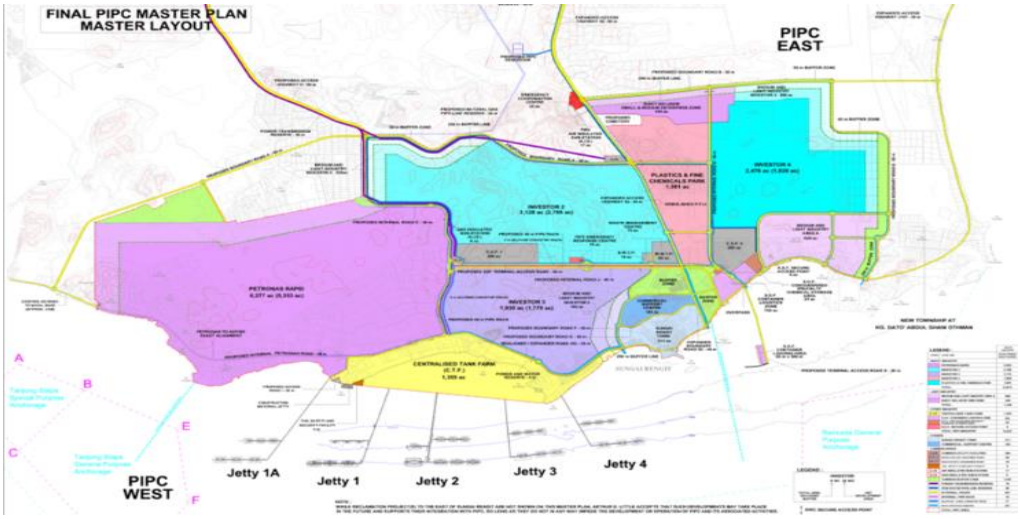

Figure 1. The Pengerang Map (Source: Johor Petroleum Development Corporation).

3. Methodology

The criterias and elements were identified and analysed through extensive literature review. The questionnaire was designed into 2 categories. The first category based on the rural road criteria selection and the second category based on rural road elements. Both the category were then analysed based on questionnaire survey.

The data collected from the questionnaire survey were analyzed by using the Statistical Package for the Social Science (SPSS) version 22.0. Then, the descriptive statistics for each question was conducted to give a better understanding of the overall results. Finally, factor analysis was performed to identify the criteria of green rural road index of the road users and the residents of Pengerang, Johor. Kaiser-Meyer-Olkin (KMO) test was used to interpretate the statistical result. The extraction communalities are estimates of the variance in each variable accounted for by the components. The communalities in this table are all high, which indicates that the extracted components represent the variables well. In rotated Factor Matrix – The table contains the rotated factor loadings which represent both how the variables are weighted for each factor but also the correlation between the variables/elements and the factor.

4. Data Analysis

The results obtained need to be fully interpreted to answer the objectives of the study. The descriptive statistics for each question was conducted to give a better understanding of the overall results. In the end, factor analysis was also conducted to identify the criteria of green rural road index of the road users and the residents of Pengerang, Johor. The data were collected among the residents of one city/municipal council as stated below. There were 75 responses received during the questionnaire survey of the studied area as stated from total 100 questionnaire distributed. From the Table 1, KMO Test for Green Rural Road Factor was achieved at 0.861 which is adequate because KMO test range is between 0.8 to 1.0. The data considered positive to analyse the green factors and criteria.

Table 1. KMO test for Green Rural Road Factor.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.861
Bartlett's Test of Sphericity	Approx. Chi-Square	213.461
	df	10
	Sig.	.000

From the analyse of communalities of Green Rural Road Factor in Table 2 below, the highest criteria shown is the Social and Safety with value of 0.729. Based on the analysis, it indicates that the social and safety with environmental and water management are the two important criteria that are crucial for rural road development. Through the literature review many researchers emphasized the rural infrastructure development gives much important to these criteria. Table 2 shows the communalities of Green Rural Road criteria that analysed through SPSS Software.

Table 2. The communalities of Green Rural Road Factor.

Criteria	Extraction
Social and safety	0.729
Environmental and water management	0.702
Material and Technology	0.676
Sustainable Design and construction activities	0.639
Energy efficiency	0.433

The correlation between criteria and the element were tabulated accordingly in Table 3. The highest variance of the criteria that fall on each factor considered the correlation between the element and the criteria is higher. For an instance, in Table 3, for elements noise mitigation control is more correlated on environmental and water management criteria with highest variance of 0.657 as compared to another variance. Highest value for each element representing the highest criteria were correlated with one another.

Table 3. Rotated Factor matrix of Green Criteria and Element.

Element	Factor Loadings				
	Social and Safety	Environmental And Water management	Material and Technology	Sustainable Design and Construction Activities	Energy Efficiency
Noise mitigation control	0.358	0.657	0.154	0.501	0.154
Good water flow	0.620	0.142	0.304	0.080	0.075
Shady area with tall trees	0.151	0.443	0.148	0.209	0.274
Building orientation	0.077	0.226	0.317	0.722	0.243
Road safety audit	0.510	0.205	0.378	0.313	-.0.309
Erosion control	0.512	0.294	0.357	0.555	-0.014
Dust Control	0.297	0.633	0.335	0.197	0.073
Water Quality Control	0.535	0.598	0.157	0.283	0.033
Pavement material	0.445	0.251	0.585	0.418	-0.013
Use LED lights	0.129	0.236	0.650	0.317	-0.047
Application of reuse, reduce, recycle	0.129	0.357	0.420	0.272	0.123
Use less street lights	-0.121	0.384	0.117	0.213	0.504
Less the usage of carbon emission equipment	0.132	0.171	0.301	0.157	0.732
Natural heritage should be preserved during road construction	0.391	0.513	0.191	0.248	0.144
Habitats should be preserved during road construction	0.546	0.487	-0.050	-0.073	0.099
Water runoff drainage system	0.576	0.202	0.316	0.181	0.138
Porous pavement for water flow	0.269	0.371	0.497	0.404	0.084
Overhead pedestrian bridge	0.567	0.429	0.240	0.188	-0.084
Exclusive motorcycle lane	0.552	0.473	0.262	0.216	-0.028

The analysed rotated factor matrix showing that the criteria and elements were well distributed accordingly. All the elements were highly correlated with the main criteria. The two elements which are building orientation and less the usage of carbon emission equipment has shown the highest correlation with sustainable design and construction activities and energy efficiency criteria with 0.722 and 0.732 respectively.

5. Result and Discussion

The results were the mean for every criterion, the factor score and the Green Rural Road Index. All the criteria have been categorized into specified criteria in Table 4. Besides, the factor scores for all criteria have been calculated. Table 4 clearly shows the arrangement of criteria according to the suitable criteria.

Table 4. The Arrangement of Green Criteria and Element.

Main Criteria	Element	Factor Loading	Mean	Factor Score	Criteria Factor Score	Total Factor Score
Social and Safety	Good water flow	0.620	4.21	2.61	18.13	48.05
	Road safety audit	0.510	4.34	2.21		
	Overhead pedestrian bridge.	0.567	4.03	2.29		
	Exclusive motorcycle	0.552	4.20	2.32		
	Erosion control	0.512	4.23	2.17		
	Water Quality control	0.434	4.29	1.86		
Environmental and Water management	Habitat should preserve during road construction	0.546	4.19	2.29	9.15	
	Water runoff drainage system	0.576	4.14	2.38		
	Natural heritage should be preserved during road construction	0.513	4.13	2.12		
	Shady are with tall trees	0.443	4.06	1.80		
	Dust control	0.633	4.20	2.66		
Material and Technology	Water quality control	0.598	4.29	2.57	7.98	
	Porous pavement,	0.497	4.20	2.09		
	Good pavement material	0.485	4.11	1.99		
	Use LED lights for roads	0.521	4.13	2.15		
	Application of 3R	0.420	4.16	1.75		
Sustainable design and construction activities	Sustainable road facilities	0.722	4.10	2.96	7.93	
	Erosion control	0.555	4.23	2.35		
	Noise mitigation control	0.657	3.99	2.62		
Energy efficiency	Less the usage of carbon emission equipment	0.732	4.00	2.93	4.85	
	Use less street lights	0.504	3.81	1.92		

The arrangement was done from the rotated factor matrix data. Besides, the mean was also analysed from every criterion. The mean was calculated from the range of the score (1-5) for every criterion of the questionnaire. The mean is very important data to calculate the factor score by multiplying the factor loadings. Every criterion had different factor score.

The social and safety criteria had the most elements according to the analysis with the highest score 18.13 compared to all other criteria. This huge different may happen due to the importance given to this criterion in all design and development of road networks. Another main reason is to make sure the development of rural road index to consider the social and safety criteria be the main reason in reducing the impact to the human and environment.

The environmental and water management, material and technology and sustainable design and construction fairly distributed between 9.15 to 7.13. The energy efficiency had the lowest score due to infrastructure works that may consume less energy. Beside the index may quantify the energy in term of natural energy usage which may reduce the usage of equipment base energy.

Figure 2 shows the percentage of criteria that have been calculated. From the figure, Social and Safety become the main criteria to be focus in Pengerang with percentage of 38%, followed by Environmental and Water Management (19%), Material and Technology (16%), Sustainable Design and Construction Activities (16 %) and the least criteria is Energy Efficiency with 10%. The gap between highest and lowest percentage of the criteria are larger as compared to My Green Highway Index, (MyGHI). MyGHI is a performance baseline standard which measure the level of greenness for current highways in Malaysia which have small gap of percentage among criteria measured with; Sustainable Design and Construction Activities (22%), Energy Efficiency (21%), Environmental and Water Management (19%), Material and Technology (16%) and Social and Safety (22%). From here, it can be concluded that rural road and urban road had different favoured criterion for the sustainable development.

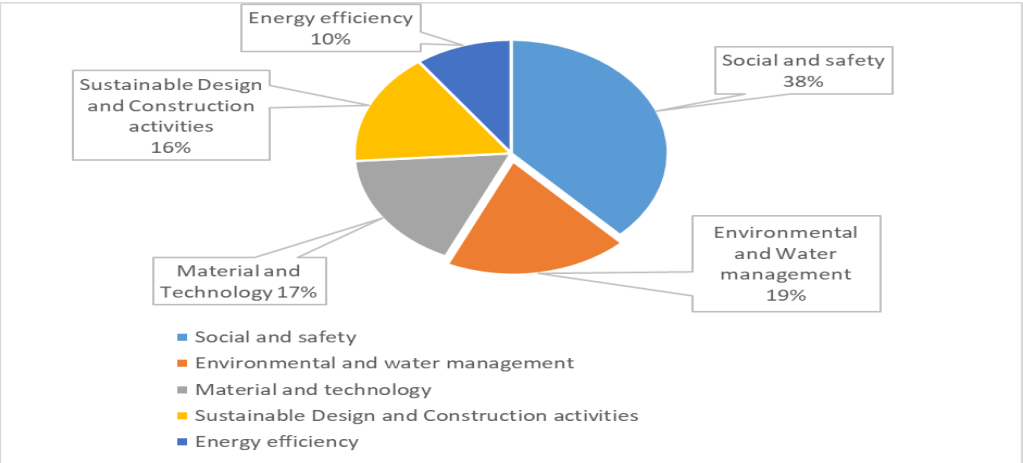

Figure 2. My Green Rural Road Index.

Based on Figure 2, social and safety criteria become the most important criteria with contributing elements of good water flow, road safety audit, overhead pedestrian bridge, exclusive motorcycle, erosion control, water quality control, habitat should preserve during road construction and water runoff drainage system. All these eight elements play an important role in defining social and safety criteria. It shows that the safety of the community within the road network is the main priority and its urgency in conserving the identity and originality of the local areas. Social and safety are very important in developing a better road networks. This is to avoid from harmful incidents and accidents in the future. For an instance, exclusive motorcycle lane is the best way to decrease the accidents of motorist in the future.

Then, second most important criteria are Environmental and Water Management, with four contributing elements, namely; natural heritage should be preserved during road construction, shady

are with tall trees, dust control, and water quality control. This criterion is also important due to plantation and farming activity that need a good watering system and fertile land for their plantation.

Third criterion is material and technology with four contributing elements of porous pavement, good pavement material, use led lights for roads, application of 3R (reduce, reuse, recycle). Next for sustainable design and construction activities criteria, it consists three elements of sustainable road facilities, erosion control and noise mitigation control. All these three elements play important roles in defining these criteria since it involves the development of rural road network. The entire road will become a failure if the criteria did not well define and addressed. Finally, the least percentage criteria are energy efficiency with two elements namely; less the usage of carbon emission equipment and use less street lights which have been discussed above.

6. Conclusion

In conclusion, all the element has been categorized into specified criteria which give a very good indication to the development of My Green Rural Road Index. Based on the results, it can be concluded that the people in Pengerang were preferred social and safety as the main priority for the development of green rural road. The priority given may due to possibility of reducing the human and environmental impacts such as accidents and pollution. Besides, this assessment tool can also benefit the rural residential area particularly in terms of socio-economic development and environmental safety.

In addition, the analysis gives the indication that the rural residents show much interest in shifting from traditional roads to green rural road because it is environmental friendly, reduce carbon emission and can conserve the natural environment and resources. It also helps to minimizes and reduces the negative impact to human and environment. Respondent in Pengerang more prefer Social and Safety criteria as the number one priority for the development of green rural road network. The criteria that categorized on social and safety are water quality control, road safety audit, exclusive motorcycle, overhead pedestrian bridge, erosion control, water runoff drainage system, habitat should preserve during road construction and water runoff drainage system. In a nutshell, developing a green rural network can give huge impact to the future generation by saving the environment with a green infrastructure networks. This also may improve the socio-economic benefit to the local community with more green facility and environmentally sound road technologies for the future generations.

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