Effect of Green Road Concept on Waste Management on Road Construction in The Banda Aceh City

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Abstract. The length of road network in Indonesia continues to increase gradually in every year. This increase will influence an availability of natural resources as the formation materials of road structures. For that, it is necessary to develop a green road concept that is able to reduce the use of natural resources and minimize the occurrence of waste materials generated. This concept is an ongoing movement that targets the construction of the planning, implementation, and usage of environmentally friendly construction products, efficient in energy and resource usage, and low cost and the achievement of appropriate construction quality. Increased waste materials in the construction process is one aspect that must be minimized in order to achieve the concept of green roads. This study aims to analyze the relationship and influence the factors of application of green road concept to waste management of road construction projects. Another purpose is to know the dominant factors affecting waste management of road construction projects. This study was done for road construction process in the Banda Aceh in Indonesia. This research uses qualitative and quantitative methods through the distribution of questionnaires. Respondents in this study were 90 units of road contractor companies has implemented projects from 2010 to 2016. The research result shows that the factor of application of green road concept that has the most influence on waste management is economic factor. The effect of this economic factor on road waste management is 18.7%. This indicates that if economic factor is enhanced, the waste management will increase on road construction project in Banda Aceh City.

1. Introduction
Road networks is an important infrastructure that supports the economy growth of a region [1]. Road construction will continue to construct in order to achieve better economic and social conditions [2]. In addition to the positive impacts of economic and social life, road construction can have a negative impact on the environment [3]. Because development will continue and cannot be restrained, what can be done is controlling and minimizing the negative impacts that arise. Since road construction is indispensable to environmental safeguards, civil engineering functions, which design road construction and other infrastructure, must always be accompanied by an analysis of the impact on the environment and its role on environmental conservation [4-5].
Daily Indonesian newspaper Kompas in year 2009 stated that of the total length of roads in Indonesia about 486,296 km long. Based on the type pavement, 59.1% of them use flexible pavement. This resulted in the large national asphalt demand of 1.2 million tons per year. Given the growth of roads that continue to increase annually, will certainly result in reduced availability of natural resources as a form of road structure. From this problem it is necessary to develop a construction process that can reduce the use of natural resources and minimize the occurrence of waste generated, through the application of the concept of green roads.

Green roads are ongoing movement that aspires to the creation of construction from the stage of planning, implementing and using environmentally friendly construction products, efficient in energy and resource usage, and low cost and achieving the right construction quality [6-8]. Increased waste in the construction process is one aspect that must be minimized in order to achieve the concept of green roads [9-10]. An increase in the amount of waste encourages humans to look for alternatives to reduce, reuse and recycle the resulting waste [11-12]. Therefore, the implementation of construction waste management can be one solution to minimize waste that can ultimately reduce costs incurred during the construction process, as well as contribute to environmentally friendly movement [6,13].

If waste reduction is done by recycling it will provide benefits in the form of project cost savings and will reduce the impact of environmental pollution [14-17]. Given the lack of awareness in applying green roads policy, the researchers felt it was necessary to analyze the effect of green roads concept on waste management performance in road construction project in Banda Aceh City. Based on the background, the formulation of the problem in this research is how the relationship and the influence between the factors of application of green roads concept to waste management on road construction project, and what factors are dominant in the application of green roads concept which influence the waste management of road construction project in the city of Banda Aceh in Indonesia. This research uses qualitative and quantitative methods through the distribution of questionnaires. Respondents in this study were 90 units of road contractor companies. The contractor company has implemented projects from 2010 to 2016, with funding sources from Aceh Province budget.

2. Green Roads Concept

2.1 Definition

According to [18], green roads are sustainable road assessment agency. This agency stated that green roads are road projects that are designed and implemented to a higher level of sustainability than ordinary road projects. The level of sustainability developed by green roads is a variety of activities from planning, road design, construction, and maintenance. These green road criteria are divided into key requirements and sustainable practices that can be volunteered.

Green roads are activities that implement environmental principles starting from the stage of financing, planning, design, construction, and maintenance of roads, and handling the impacts of climate change [19]. Benefits in green roads include the following:

i. Environmental benefits (ecocentric) are to reduce the use of materials, fossil fuels, water, air pollution, greenhouse gas emissions, water pollution, solid waste, and able to recover/shape habitats; and

ii. Benefits for humans (anthropocentric) is to improve access, mobility, health and human safety, local economy, awareness, aesthetics, and reduce life cycle costs.

2.2. Concept Factors for Green Roads Implementation

The concept of green roads implementation on sustainable road development are several factors, can be shown in Table 1.
Table 1. Concept factors for green roads implementation [20]

| No | Factors  | Indicators                                                                                                                                 |
|----|----------|-------------------------------------------------------------------------------------------------------------------------------------------|
|    | Social   | Road user access equality  
Behavior change and capacity building  
Protect and develop culture and history  
Community participation  
Health protection (noise safety)  
Road safety audit  
Notice (newspaper)  
Two-way discussion (workshops, open discussions, and polls)  
Other free criteria/innovation |
| 1  | Economy  | Planning and designing of roads in accordance with applicable standards  
Selection of appropriate technology and equipment  
Quality control of work  
Material, and water transport savings during implementation  
Energy savings (saving fossil fuels, using solar/other energy)  
Conservation of material use (reuse, recycle, local material) and natural resources  
Service providers are certified ISO quality management and environmental management  
The use of traffic signal lights is coordinated by reducing vehicle stop delay by up to 40%  
Flood cost analysis  
Analysis of road pavement costs  
Provision of pedestrian paths, cyclists and public transport  
Provision of pedestrian access to stops/terminals  
Provision of pedestrian complementary facilities, cyclists (pedestrian lights, benches, bicycle parking places, and bins)  
Other free criteria/innovation |
| 2  | Environment | Environmental and ecosystem protection (animals)  
Air protection  
Light settings  
Regulating water use at the project site  
Energy regulation  
Reuse of old materials (reuse, recycle)  
Planting trees and plants that can reduce erosion  
Waterproof surface setting  
Installation of auxiliary apparatus for at least 90% hot pavement mixture  
Regulation of motor vehicle usage at project site  
The use of local materials is used 60%-95% of the material needs  
Drainage arrangements by providing absorption ponds, water retention, rain-catch gardens  
Protection of natural or artificial lakes closest to road projects  
Added access for animals  
Other free criteria/innovation |
Social factors, is the implementation of roads must meet the needs and improving the quality of road users travel, safety (reduction of the number of deaths and the number of accidents), and the needs of road users, such as mobility and accessibility, to perform activities comfortably and in good health. Economic factors, is the implementation of roads using natural resources of an area, to improve the prosperity of local people, and make savings, in order to reduce development costs. While environmental factor, is the implementation of the road with regard to protection and reduce environmental damage.

2.3. Prospect for Green Roads Implementation
According to [21], the prospect of applying green road construction in Indonesia is very useful and interesting, green concept should be based on the life cycle of construction projects starting from planning, procurement, implementation, operation/maintenance, and deconstruction/demolition. All activities at every stage of the project life cycle must be created that impact on the environment [22]. The real shape of green roads construction in Indonesia is evident from the current government policy regarding mass transportation and environmentally friendly transportation systems such as Mass Rapid Transit (MRT), Electronic Road Price (ERP), and Environmentally Sustainable Transport (EST).

2.4. Construction Waste Management
According to [23], management is identical to organize or arrange something with functions. Waste management involves the collection, transportation, storage, maintenance, recovery and disposal of waste. Waste management as a means of controlling disposal costs, as well as facilitating alternative methods such as recycling and reuse to reduce the amount of waste [24]. Waste management planning is defined as a strategy document developed to achieve waste management and prevention objectives, adding restrictions on environmental impacts of waste on health and the environment [25].

According to [26], the main steps in waste management are reducing, reuse, recycle, recovery, and disposal. All five are strategies to reduce the amount of waste generated. Implementation of waste management on construction projects can be useful as: cost savings and profit maximization; reduce the demand for landfills; improved resource management; increased corporate image; and increased productivity and quality.

Construction waste management is defined as a comprehensive, integrated, and rational system approach to achieving and maintaining acceptable environmental quality and supporting sustainable development [24, 27]. There are many studies conduct around the world to improve the construction waste management [28-37].

3. Research Methods
3.1 Determining Research Variables
The independent variables in this research are the factors of application of green roads concept (X), while the dependent variable is waste management (Y).

3.2 Questionnaire Design
The type of questionnaire used in this study is a closed questionnaire. Respondents only choose from the answers that have been provided by researchers. In this case the questionnaire is divided into two parts, which can be described as follows.

i. Questionnaire part A, this questionnaire is characteristic of respondent. Measurement of answers according to their characteristics.

ii. Questionnaire part B, this questionnaire is the factors of application of green roads concept is as independent variable and waste management is as dependent variable. Measurement of answers using Likert scale, where each answer can be disclosed by assessment.
3.3 Determining the Population

The population is intended for road contractor company in Banda Aceh city. Based to the rule of Indonesian government and according to the amount of construction contract, contractors are qualified as little contractor ($K_1$, $K_2$, $K_3$), medium contractor ($M_1$ and $M_2$) and big contractor ($B$). In this study only focused to $K$ and $M$ category. Based on Construction Service Development Board of Indonesia from data on October 8, 2016, the number of contractor companies was obtained by 830 contractors.

Samples that are representative parts of the population can be known by Slovin's Equation. The level of trust used in this study is 90% and the error rate is 10%. The value of this error rate depends on the level of confidence desired by the researcher. Thus the number of samples obtained in this study are as many as 90 contractor companies.

The sampling technique used in this study is purposive sampling, done by taking intentional sampling by doing certain considerations. This consideration is based on a contractor company that has completed a road construction project in Banda Aceh city from year 2010 to 2016, with funding sources from APBA or Aceh Revenue and Financing Budget.

3.4 Data Processing

This data processing is to perform reliability test, which is done to know reliable or not reliablenya a variable on the questionnaire controlled by the value of Cronbach Alpha > 0.6.

3.5 Data Analysis

This data analysis includes descriptive analysis, simple correlation analysis, and and multiple linear regression analysis using SPSS version 22 software. This analysis can be explained as follows.

i. Descriptive analysis, used to know the characteristics of respondents;

ii. Simple correlation analysis, used to know the closeness of the relationship between green roads concept implementation factor to waste management in road construction project in Banda Aceh city partially; and

iii. Multiple linear regression analysis was used to determine the effect of green roads concept implementation factors on waste management in road construction project in Banda Aceh City.

4. Result and Discussion

Reliability test results for each variable that has been processed, summarized in Table 2. Table 2 shows that all the variables in the questionnaire had Cronbach Alpha > 0.6. Thus the reliability test performed on all variables is all reliable, so it can be continued on the data analysis.

| No. | Variable               | Cronbach Alpha | Information |
|-----|------------------------|----------------|-------------|
| 1   | Social factors ($X_1$) | 0.939          | Reliable    |
| 2   | Economic factors ($X_2$) | 0.960          | Reliable    |
| 3   | Environmental factor ($X_3$) | 0.964          | Reliable    |
| 4   | Waste management ($Y$)  | 0.935          | Reliable    |

4.1 Relationship Factors Implementation of Green Roads Concept

This simple correlation analysis has output in the form of a relationship through the magnitude of the Pearson correlation coefficient, and the presence or absence of a relationship through a significant level should be < 0.05. Pearson correlation that have been analyzed, can be seen in Table 3. The table 3 above shows that the factors of application of green roads concept have one form of relationship to waste management, which is very high. Social, economic, and environmental factors partially have a very high relation with Pearson.
coefficient of 0.886, 0.942, and 0.879, to waste management of road construction projects in Banda Aceh City.

| No. | Relationship variable | Pearson Correlation | Form of Relationship | Significance <0.05 |
|-----|-----------------------|---------------------|----------------------|-------------------|
| 1   | X₁ – Y                | 0.886               | Very high            | 0.000             |
| 2   | X₂ – Y                | 0.942               | Very high            | 0.000             |
| 3   | X₃ – Y                | 0.879               | Very high            | 0.000             |

4.2 The Effect of Implementation Factors of Green Roads Concept

Multiple linear regression analysis result between X and Y variables are shown in Table 4 regression models formula obtained are: \( Y = 0.459 + 0.122X₁ + 0.187X₂ + 0.080X₃ \).

| Variable                        | Regression Coefficient (b) | t-value | Sig |
|---------------------------------|----------------------------|---------|-----|
| Constants                       | 0.459                      | 0.566   | 0.573|
| Factor social (X₁)              | 0.122                      | 2.720   | 0.008|
| Factor economy (X₂)             | 0.187                      | 5.200   | 0.000|
| Factor environment (X₃)         | 0.080                      | 3.056   | 0.003|

\( F_{count} = 225.300 \)

\( Sig = 0.000 \)

\( R² = 0.887 \)

Multiple linear regression coefficient indicates that the factors of application of green roads concept all have a positive influence on waste management of road construction project in Banda Aceh City. This positive influence implies that if there is an increase of 1 contractor company, which applies each factor of application of green roads concept, the waste management of road construction project in Banda Aceh City will increase. The magnitude of this increase in waste management, is proportional to the regression coefficients generated by each factor of application of green roads concepts. In this case the improvement of waste management of road construction project on social factors is 0.8%, economic factor is 18.7%, and environmental factor is 12.2%.

The coefficient of determination indicates that social, economic and environmental factors simultaneously have contributed 88.7% to the waste management of road construction projects in Banda Aceh City. The remaining 11.3% is influenced by other factors not examined in this study.

4.3 Dominant Factors on Implementing the Green Roads Concept

The dominant factor in applying green roads concept which influenced waste management of road construction project in Banda Aceh City, has been analyzed through multiple linear regression. The dominant factor in applying green roads concept which influences waste management of road construction project in Banda Aceh City, is economic factor.

This economic factor is the implementation of roads using the natural resources of a region, to increase the prosperity of the local people, as well as make savings, in order to reduce development costs. The interpretation as the dominant factor is, if there is an increase of 1 contractor company applying the economic factor, the waste management of road construction project will increase by 18.7%. This economic factor can be applied by way of planning and designing roads according to applicable standards, selection of appropriate technology and equipment, work quality control, saving
of material transportation and water during execution, energy saving (fossil fuel saving, using diesel/other energy), saving the use of materials (reuse, recycle, local materials).

The next economic factors such as: natural resources, service providers are certified ISO quality management and environmental management, the use of coordinated traffic signal lights by reducing vehicle stop delays by up to 40%, flood cost analysis, pavement cost analysis roads, providing pedestrian paths, cyclists and public transport, providing pedestrian access to stops/terminals, providing pedestrian complementary facilities, cyclists (pedestrian lights, benches, bicycle rides, and garbage cans), and other innovation criteria.

4.4 Comparison with Previous Research

Research conducted by [35], shows that the understanding between planners, contractors and academics has significant differences in each of the principles of sustainable road development. Understanding of contractor on social aspect is equality of access of road user with mean 2.7, in economic aspect is energy saving (fossil fuel saving, using diesel/other energy) with mean 2.8, and environmental aspect is greening with mean 3.1. Understanding planners on the social aspect is the equivalence of access road users with a mean of 2.89, on the economic aspect is to maintain the quality of work with a mean of 3.0, as well as the environmental aspect is afforestation with mean 3.0. Understanding academics on social aspects is health protection (noise and safety) with mean 3.15, on the economic aspect is maintaining the quality of work with mean 3.15, and environmental aspect is green with mean of 3.08. In this research the application of green roads concept in Banda Aceh City is done based on contractor understanding.

Contractor understanding on social factors is community participation, and two-way discussion (workshops, open discussions, and polls) with mean 4.40, on economic factors is the reuse, recycle, local materials and resource saving, and other free/innovative criteria with mean 4.40, and on environmental factors is the use of local materials used as much as 60%-95% of material requirements with a mean of 4.59. Each of these factors has its own contribution in the development of sustainable roads or green roads. Social, economic and environmental factors are expected to be applied in the planning, implementation and maintenance of road infrastructure so that the concept of green roads can be achieved in Banda Aceh City.

Research conducted by [36], shows that the concept of green road construction implementation in Indonesia needs to pay attention to the planning and scheduling of construction projects, source and material cycle, work site protection plan, waste management, storage, and material protection. In relation to the results of the research, the concept of green road construction implementation in Banda Aceh City is necessary to pay attention to community participation, two-way discussion (workshops, open discussions and polls), reuse, recycle, local materials and materials saving, and the use of local materials is used as much as 60%-95% of material requirements.

Research conducted by [37], shows that Construction Activities (CA) has the most influence on the application of green criteria based on sustainability interests. The research is different from the research done on the road construction project in Banda Aceh City. In this case the factors of applying green road concept are reviewed on waste management. The factor of application of green road concept that has the most influence on waste management of road construction project in Banda Aceh City is economic factor. The effect of this economic factor on road waste management is 18.7%.

5. Conclusion and Suggestion

5.1. Conclusion

i. Partially social, economic and environmental factors all have a very high relationship to waste management of road construction projects in Banda Aceh City.
ii. The factors of application of green roads concept all have a significant effect on the waste management of road construction project is 88.7%.

iii. The dominant factor in the application of green roads concept which influences waste management of road construction project is an economic factor. This indicates that if the economic factor in Banda Aceh City is enhanced by the contractor, then waste management will increase.

5.2 Suggestions
i. It is advisable to contractors to pay attention to social, economic and environmental factors, because each factor has its own contribution in the development of green road road in Banda Aceh City.

ii. It is advisable to contractors to apply social, economic and environmental factors in the planning, implementation and maintenance of roads so that the concept of green roads can be achieved in Banda Aceh City.

iii. It is suggested that contractors to implement green roads should take into account community participation, two-way discussions (workshops, open discussions, and polls), reuse, recycle, local materials and natural resource use, and local materials use 60% -95% of material requirements.

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