The Best Construction of the Regional Road to Support CO_2 Emissions Reduction in Critical Area: A Case Study of Maros-Watampone Road

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1. Introduction

Road is a public good; therefore, to provide it should be by the government because nobody wanted to pay for something, which had benefited for all. How much money should be provided by the Government for a road development; it is an issue. We cannot apply price system to reach efficiency of economic resources for provided it. Instead by a vote to do it because the public neither can explicate their references of the public goods. In a democratic society, preferences and willingness to pay for public sectors should be a way of voting.Distribution and a way of a vote are determinant of a result of voting.

Road construction is a specific sector which the professional reference is the one way of public participation in making of decision.Professional is a community who expert in road planning and development. Complexity of knowledge and understanding about road planning and development of the professional can be simplified through by an Analytic Hierarchy Process (AHP) approach. This is an approach a mathematic concept to make a structure of a problem by matrix.All factors are arranged and selected then descending in hierarchy structure to criteria and alternatives in successive levels. Determination of criteria of road construction selection is not the main parameters for road construction but should be considered in the decision-making.

While the construction sector is one of the major contributors to the economic development of Indonesia, instead of the construction process and operation had a fairly large consumption of energy and created of CO_2 emissions significantly. We need to effort to estimate an amount of CO_2 emissions that potential produce by construction activities in order to do prevention or improvement of the environmental impact.The best construction by selection of public preferences must support the CO_2emissionsreduction program of the Government.

Government of Indonesia had a limited budget for the development implementation.Therefore,the result of selectioncan be conducted by an efficiency of economic resource evaluation. The road investment benefited purpose for community. The evaluation method of the economic resource provides an integrated framework to investment evaluation from a public standpoint. Method of evaluation calculated based on: Benefit-Cost (B/C) analytic, Net Present Value (NPV) analytic and Internal Rate of Return (IRR) analytic; to be proved that reference of public is the best choice for implementation.

2. Research Methods

Method of selection construction by public and the evaluation of efficiency of the economic resource through the approach, namely:

2.1. AHP for selection of the road construction type

This approach built formed matrix of relative weights among the criteria performed by the value of the preference. The method used is AnalyticalHierarchyProcess (AHP) todetermine the choice type ofconstruction.This methodwas first developedbySaaty(1988)and is commonly usedby decision-makers to be decided ona policyby performingthe synthesisofseveral optionsin a singlemethod. The core ofthis analysisis totransformasubjectiveassessmentbecomesawholehas a valueorweight.

Acquisition ofdataweighting isderivedfromthe analysisofthe surveyinterview, inwhich respondentsare faced withthe question ofhow largeaninterestratecriterioncomparedwithother criteria. The criteria usedare theresults of identificationofthe things thathave amajor influence onchoicethantoachieve thegoal. Relative of weightsamongthe criteriausedtoobtaincomparisonsbetweencriteriaweightingarenormalizedand determine thelevel of importanceamongthe criterionvariablescompared.Relative preference values obtained through analysis of interviews with questionnaires to respondents whom the importance level among the elements using a scale of 9.

Respondents were selected are the ones who have the technical expertise or knowledge of roads and bridges. They consisted of government officials, planners, engineering and academia. The respondents are not representative of the population as a whole because their numbers a bit so that each group represented by 10 people. However, overall it is considered that the respondents have representing of the community.

Respondentsare assumed tobe consistentin providingan assessment ofeach pair ofcriteriaandall*n* criteriahave the same valuewhen comparedagainst itself.

The results ofcalculationof eachrowin thematrixcomparisons willobtainthe value of eigenvectorwhich is theweightsvalue ofthenormalizedaverageof eachfactorin eachrow. The weightmatrix ofpair-wise comparisons has acharacteristicmaximumvalueof nis positive, both simpleandcharacteristicvectorassociatedwithapositive(Theoremof PerroninGarminia, 2010). Therefore,can berepresentedthat thepair wise comparisonmatrixhas aconsistency indexis zero.

Selection criteria were compared using a survey by PT. Yodya Karya and previous study(Badriana, 2009) of the problems found in the Maros-Watampone road namely: benefits, environmental, economical, cost of construction, technology, maintenance costs, esthetics value, ease handling of implementation, and time of construction.

The criterion for selection of the type of construction was made in a hierarchy of decision-making so that the selected alternative able to accommodate all aspects of the problem. Top level shows where the selection is the best type of construction. On the second level are the criteria that influence the selection. For the third level is going to alternative construction selected by considering the criteria on the second level. Selection hierarchy is shown in Figure 1.

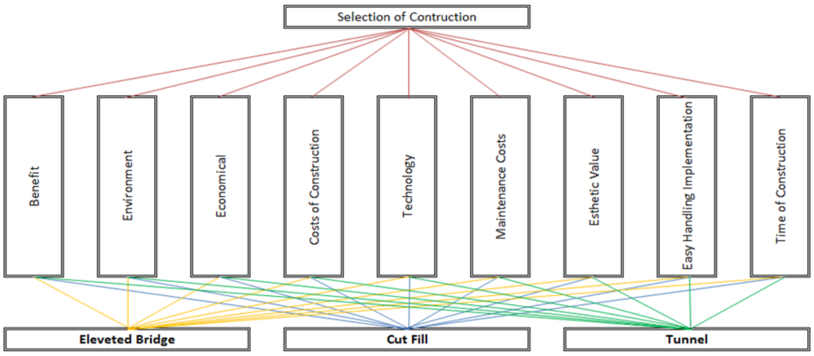

Figure 1: Selection of Alternative Handling Geometric Hierarchy

2.2. CO_2 emissions calculation

Calculate the approximate number of environmental impacts such as CO2 emissions caused by an alternative construction to using the value of emission factorresults of several studies of the scientific literature published. Due to limited data and literature, we made a lot of assumptions to simplify the calculation. Assumed the value of emissions factor was used to have indicators and geographical conditions of the same. The main construction was using the results of the greenhouse-gas calculations performed by Kato et al (2005), Sripple (2001), and Rajagopalan (2007). Emissions caused by transportation mode refer to the results of scientific research Rose (2010). It is important to note that the calculation results depend on the actual construction design.

2.3. Efficiency of economic evaluation

TheimplementationofthepolicycanworkwelldoneprovingittheoreticallywithcalculatingeconomicvariablesthroughtheanalysisoftheCostBenefits(CBA)forthebestconstructiontosupportdecisionmaking.Thisanalysisisusedforactivitiesthatcouldpotentiallyinterferewiththeenvironmentandthepublicinterest.Theconceptisverysimple,whichmeasuresthevalueofthebenefitsandcostsofanactivityarecomparableinsize.Activitieswillleadtotheallocationoffactorsofproductionmoreefficientifthevalueofthebenefitisgreaterthanthevalueofthecost.TheHighwayDevelopmentandManagementIVmethodcalculatedVehicleOperatingCosts(VOC) basedonthepreliminarydesignsimulationsassumingthecurrentpriceandgeometricparameters.ComponentofthevalueoftimewascalculatedbyusingIntegratedRoadManagementSystem(IRMS)andtheapproachofGrossOutput(HumanCapitalApproach)togetthecostofaccidents.
Expansion of the analysis of benefits and costs is to use criteria Net Present Value (NPV) to calculate the level of investment feasibility, Internal Rate of Return (IRR) and Benefit Cost Ratio. Test sensitivity was calculated based on the eligibility conditions optimistic scenario (increase of the benefits cost by 25% and investment costs decrease by 25%) and the condition of pessimism (decrease of the benefit cost by 25% and investment costs increase by 25%).

3. Case Study

Maros-Watamponeroad is located in South Sulawesi, Indonesia, where the road built by the Dutch government, and important for regional economic activity between South Sulawesi Province and Southeast Sulawesi Province. This road has a length of 145km with a width average of 6 meters and cross some mountain areas with steep contour's conditions.

Since2007 until 2009, the Government has conducted a study and discussion for the planning of road development in an effort to improve the performance of Maros-Watamponeroad. This plan recommended to improvement three alternate geometric road construction options that can be applied to the elevated bridge, cut-fill and tunnel system. Implementation of the three construction alternatives could potentially have a negative impact on the environment. Thus, special attention is needed to the topography and geology, in particular, the choice of construction techniques and methods in order to maintain the sustainability of ecosystems especially in the National Parks and heritage areas on the sides.

4. Analysis Results

4.1. Decision Making by AHP

The results of the pairwise comparison showed that the preferences of the respondents are consistent in providing options. This is evidenced by inconsistencies value less than 0.10 (0.08), and the weight of the criterion and alternative options can be seen in Table 1.

The existence of the road will make increased mobility so that the economic growth of the area, traffic safety and comfort will be increased as well. Service delivery across between the provinces no longer delayed so that the freshness of the food delivery can be assured.

Table 1: The Weighting of Criteria and Alternatives

Criteria	**Global Weighting**	**Alternatif Weighting**			**Inconsistency**
		Elevated Bridge	**Cutfill**	**Tunnel**	
Benefit	0.300	**0.534**	**0.150**	**0.316**	0.03
Environment	0.224	0.519	0.304	0.177	0.02
Technology	0.130	0.493	0.311	0.196	0.05
Economical	0.104	0.570	0.270	0.160	0.03
Construction Costs	0.081	0.550	0.210	0.240	0.02
Maintenance Costs	0.054	0.523	0.284	0.193	0.09
Esthetic Value	0.041	0.489	0.332	0.180	0.09
Easy Handling Implementation	0.038	0.581	0.282	0.137	0.04
Time of Implementation	0.029	0.534	0,.316	0.150	0.03
Inconsistency	0.090	0.528	0.248	0.223	**0.08**
Priority		**1**	**2**	**3**	

4.2. Application of the Elevated Bridge Construction

Table 2 shows that the geometric changes of an existing condition to the implementation of the construction of an elevated bridge. There are several geometrical conditions, which cannot be adapted to the National Road Standard because we keep trying to be realistic with the conservation zones and critical area by use the lower level of service.

Table 2: The Geometric Change Parameters

Road Condition	Before Implementation	After Implementation	Unit
Length	10	11.5	Km
Width	4.5	7	M
Width shoulder	1	2	M
Topography condition	Hill	Flat	-
Average slope (RR)	22.5	2.5	m/km
Average derivate (FR)	22.5	3.5	m/km
Slope + derivate (TTR)	45	5	m/km
Degree of Curve (DTR)	200	15	°/km
Surface condition (IRI)	5	7	m/km
Average speed	40	65	Km/jam

4.3. Construction Impacts on CO_2 Emissions

Table 3illustrates that the amount of CO_2 emissions and the relative contribution of the main construction, maintenance and transportation of type of existing construction and two construction alternatives. Cut and fill construction is post-dispatch construction, and therefore, we cannot display the data on the number of the resulting CO_2 emission.

Table 3: Estimate the Total Emissions Produced by Each Type of Alternative Construction

Type of Construction	Ton CO_2/KM			
	Main Construction		Transportation	Total
	Construction	Maintenance		
Elevated Bridge	1.05	0.03	0.23	1.31
Tunnel	1.50	0.07	0.23	1.79
Cut fill	NA	NA	NA	NA
Asphalt Surface	0.05	0.01	0.29	0.35

4.4. Analysis of the Economic Efficiency

4.4.1. Component of Cost Benefit

Vehicle operating costs was decrease after the implementation of the construction can be seen in Table 4 that shows that the vehicle type truck having a lot of benefits caused by the project.

Table4:Operational Cost of Vehicle (Before and After the Project)

Vehicle	Before Project	After Project	Different VOC
Sedan/city car	3,720	3,133	588
Sport utility vehicle	4,678	3,740	938
Mini Bus	8,140	7,603	537
Bus	11,568	7,584	3,984
Light Truck	7,725	6,670	1,055
Medium Truck	12,901	11,208	1,693
HeavyTruck	14,813	8,671	6,142

Geometric changes will have a major impact on travel time. The average vehicle travel time reduction of 20-30% of original condition. The accident rate will be decreased. Overall travel time changes before and after project can be seen in the following table:

Table 5: Value Time Travel Before and After the Project

Vehicle	Before Project	After Project	Time Rate
Sedan/city car	73,821	45,428	28,393
Sport Utility vehicle	53,176	32,724	20,452
Mini Bus	106,352	65,447	40,905
Bus	212,703	130,894	81,809
Light Truck	14,960	9,206	5,754
Medium Truck	14,960	9,206	5,754
Heavy Truck	14,960	9,206	5,754

4.4.2. Feasibility and Sensitivity Analysis of Investment

Table 6 illustrates that the value of the benefits arising from the application of elevated bridge construction at the time and in different conditions. The values of the evaluation of the implementation of this work are placed in the scale of priorities and investment feasible.

Table 6:Sensitivity Test on 25% ofProfits and Costs Change

<table>
<tr><th>Test</th><th>NPV (in Billion Rupiah)</th><th>IRR (in Billion Rupiah)</th><th>BCR (12%)</th><th>BCR (15%)</th></tr>
<tr><td>Scenario 1: without accident cost saving</td><td rowspan="2">899,849</td><td rowspan="2">20.07%</td><td rowspan="2">2.78</td><td rowspan="2">2.21</td></tr>
<tr><td>Condition</td></tr>
<tr><td>Test 1: cost investment up 25%, benefit down 25% (condition pessimistic)</td><td>385,052</td><td>17.91%</td><td>1.78</td><td>1.41</td></tr>
<tr><td>Test 2: cost investment down 25%, benefit up 25% (condition optimistic)</td><td>1,459,639</td><td>21.32%</td><td>4.34</td><td>3.45</td></tr>
<tr><td>Scenario 2: with accident cost saving</td><td rowspan="2">1,078,678</td><td rowspan="2">20.36%</td><td rowspan="2">3.09</td><td rowspan="2">2.45</td></tr>
<tr><td>Condition</td></tr>
<tr><td>Test 1: cost investment up 25%, benefit down 25% (condition pessimistic)</td><td>563,881</td><td>18.60%</td><td>2.03</td><td>1.61</td></tr>
<tr><td>Test 2: cost investment down 25%, benefit up 25% (condition optimistic)</td><td>1,638,468</td><td>21.43%</td><td>4.73</td><td>3.75</td></tr>
</table>

5. Conclusions

An AHP method has been applied to select of the best type construction road on Maros-Watampone, Indonesia, for decision-making. To support these decisions for handling geometric construction on Maros-Watampone roads should consider the non-economic aspects such as benefits, environment, technology, economic, construction costs, maintenance costs, esthetic value, easyforimplementation and time of implementation. All criteria have to contribute with significantly in construction process and operation for keep environmental sustainable. Criteriaof considerationare analyzed using AHP, where the level of knowledge and information of the respondents affects the weights in this analysis.

AHP analysis showed that elevated bridge construction is the best alternative for geometric improvements at Maros-Watampone road. This decision is supported by the results of a simple analysis of the environmental impact and economic aspects of the evaluation of the selected alternative. Overall, the selection of elevated bridge construction provided great benefits, have a little impact on the environment, the achievement of geometric standards through technology, and the value of BCR> 1.0 which indicates that the cost of the benefit is greater than the cost of investing in a state

of optimistic and pessimistic. Besides, it has artistic value that can support increased conservation area as an area of natural and cultural heritage.
The calculation of the ecological impacts out of the scope this project will work but need to be prepared as a follow-up of the value of CO_2 emissions generated after a simple calculation. Future study should be concentrated on the environmental impact of the energy consumption, especially in the construction and transportation activities thoroughly involving all components in the construction, maintenance and transportation.

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