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**Conference Paper**

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# **Public Participation in Selection of the Road Construction by Analytic Hierarchy Process for Supporting of CO<sub>2</sub> Emissions Reduction: Maros-Watampone Road Case**

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## **Abstract**

Maros-Watampone road passes through a critical geometric conservation area where it is a barrier to the development improvement. Previous studies recommend that three proposed alternative constructions can be used: 1. Elevated Bridge, 2. Cut and Fill, 3. Tunnel system. The Government invited community members to participate in selection the best type of construction that can be applied at their region. That is one way to make the decision in the good governance process for the democratic country system. By using the Analytic Hierarchy Process (AHP), the results showed that the criteria of benefits (0.300) as a major factor in determining the priority of construction and the second is environmental criteria (0.224). In fact, construction cost (0.081) and maintenance criteria (0.054) had no significant effect. An elevated bridge construction is the most suitable construction to be applied (0.528), followed by cut and fill construction (0.248) and the tunnel system (0.223) respectively. The higher contribution of benefit and environmental criteria are indicated that the community preferences cannot be measured with price system.

Besides fairly large energy consumption, the construction activity created CO<sub>2</sub> emissions simultaneously. Thus a simply estimation of the CO<sub>2</sub> emissions indicates that the elevated bridge construction has the lowest (1.31 TonCO<sub>2</sub>/km) emissions than the tunnel construction (1.79 TonCO<sub>2</sub>/km). The decision-making process showed that the public started to pay attention for their quality of life, and the environmental effect caused by their development activity.

On the other hand, the Government has a limited budget to choose the best development program; therefore, we made an evaluation of the efficiency of economic resources based on: 1. Benefit-Cost analysis, 2. Net Present Value (NPV) analysis, 3. Internal Rate of Return (IRR) analysis. By the investment feasibility evaluation of the best construction can be proven that the public decision is the right choice to support the government decision. Public participation in economic development is the one way to reach efficiency of economic resources.

**Keywords:** *Public Participation, Decision-making, Analytic Hierarchy Process, CO<sub>2</sub> Emissions, Efficiency of Economic Evaluation*

JEL codes: R, R5, R58

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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<sub>2</sub> emissions significantly. We need to effort to estimate an amount of CO<sub>2</sub> 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<sub>2</sub> emissions reduction program of the Government.

Government of Indonesia had a limited budget for the development implementation. Therefore, the result of selection can 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. Community into the Road Development**

Movement of the people and goods is like the lifeblood which created welfare and prosperity that made of the Government development priority on the road network (Keiron Audain,

2011). Population densities tend to follow the pattern of the way so that the existence of a new road will improve the sustainable economic growth (Donald R. Glover, 1975; Miyata et al, 2008). There are two reasons to build or widen roads, namely: one, increase road capacity by adding lanes or building new construction in line with pre-existing; two, build new roads in the area of development ([www.moderntransit.com](http://www.moderntransit.com)). Roads have both horizontal and vertical curvature should be designed to fit the terrain to achieve the desired aesthetic qualities and be in harmony with the surrounding environment (Mackay City Council, 2008).

Lately environmental issues have gained a lot of public attention, where the people have become more aware that the consumption of goods, and services because rendered both of them have an impact on the natural resources. The public and private sectors have started taking a keen interest in reducing the adverse effects, and in evolving methods for prevention of these impacts. Choosing the best construction and material is one of the tools for evaluating the adverse impacts of our actions that have caused to the environment and the society for sustainability. The economic criteria, aesthetic value, environmental factors and design factors, are need to consider before deciding for the construction, especially for material of construction (Hovarth, 1997).

Road construction had benefits and consequences. Maximize safety, served community, shorten the distance and travel time, increased economic output and quality of life, is the purpose of construction of roads where the speed of the vehicle greatly affects the achievement of benefits. One that limits the achievement of maximum service from the street is the geometric conditions (Zheng, 1997). Required careful planning and good construction for roads located on steep slopes because the impact on sedimentation (Beverly C W., et al, 2001; Reid 1981). For regions with difficult geographical conditions will significantly increase the cost of construction so the construction of roads must be recommended realistic taking into account the lower Level of Service (LOS) and environmental constraints ([www.sdcountry.ca.gov](http://www.sdcountry.ca.gov)).

Planning should be able to integrate all these factors into account environmental and human change as the main factor forming processes against environmental policy (Mac Harg, 1969). The success of a design depends on the character's design of the model and the responses to the environment to create a balance between the designs of the overall environment (Hough, 1984).

Road infrastructure in Indonesia is a vital role in national transportation, which serving of passenger approximately 92% and 90% of transportation on the existing road network. The continuous infrastructure development gives a positive impact for the regional economic

competitiveness in the national economic and increase of the national economic in international competitive level (Ministry of Public Works of Indonesia, 2010). This purpose is according with Indonesia's economic development strategy that is pro-green, pro jobs and pro poor. The infrastructure policy expected to choose the best alternative by public that is considered accurate yield benefits that can alleviate the problem (Simon H, 1947).

### **3. Research Methods**

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

#### *3.1. 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 Analytical Hierarchy Process (AHP) to determine the choice type of construction. This method was first developed by Saaty (1988) and is commonly used by decision-makers to be decided on a policy by performing the synthesis of several options in a single method. The core of this analysis is to transform a subjective assessment becomes a whole has a value or weight. Acquisition of data weighting is derived from the analysis of the survey interview, in which respondents are faced with the question of how large an interest rate criterion compared with other criteria. The criteria used are the results of identification of the things that have a major influence on choice than to achieve the goal. Relative of weights among the criteria used to obtain comparisons between criteria weighting are normalized and determine the level of importance among the criterion variables compared. Relative preference values obtained through analysis of interviews with questionnaires to respondents whom the importance level among the elements using a scale of 9. Table 1 shows the scale of the interest rate criterion, as follows:

Table 1: The Scale of Assessment between the Criteria (Saaty, 1990)

Interest Rate	Definitions	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Moderate favor than the other
5	Essential importance	Strong favor than the other
7	Very strong importance	Strongly favored and dominant than the other
9	Extreme importance	The favored highest of
2, 4, 6, 8	Intermediate values	When compromise is needed
Reciprocals	If the inverse element $i$ has one of the above rates when compared to element $j$ , then it has the reciprocal value when compared to the element $i$ .	
Rational	Rations arising from the scale	If consistency were to be forced by obtaining $n$ numerical values to span the matrix

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.

Respondents are assumed to be consistent in providing an assessment of each pair of criteria and all  $n$  criteria have the same value when compared against itself. Each criterion has  $n$  elements, namely:  $w_1, w_2, w_3, \dots, w_n$  where the value of the comparison  $n$  criteria can be described by the equation:  $\frac{1}{2} n (n-1)$ . Overall comparison of each pair in this analysis forms the reciprocal square matrix as illustrated below:

	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	.....	A <sub>n</sub>
A <sub>1</sub>	w <sub>1</sub> /w <sub>1</sub>	w <sub>1</sub> /w <sub>2</sub>	w <sub>1</sub> /w <sub>3</sub>	.....	w <sub>1</sub> /w <sub>n</sub>
A <sub>2</sub>	w <sub>2</sub> /w <sub>1</sub>	w <sub>2</sub> /w <sub>2</sub>	w <sub>2</sub> /w <sub>3</sub>	.....	w <sub>2</sub> /w <sub>n</sub>
A <sub>3</sub>	w <sub>3</sub> /w <sub>1</sub>	w <sub>3</sub> /w <sub>2</sub>	w <sub>3</sub> /w <sub>3</sub>	.....	w <sub>3</sub> /w <sub>n</sub>
⋮	⋮	⋮	⋮		⋮
⋮	⋮	⋮	⋮		⋮
A <sub>n</sub>	w <sub>n</sub> /w <sub>1</sub>	w <sub>n</sub> /w <sub>2</sub>	w <sub>n</sub> /w <sub>3</sub>	.....	w <sub>n</sub> /w <sub>n</sub>

The results of calculation of each row in the matrix comparisons will obtain the value of eigenvector which is the weights value of the normalized average of each factor in each row. The weight matrix of pair-wise comparisons has a characteristic maximum value of  $n$  is positive, both simple and characteristic vector associated with a positive (Theorem of Perron in Garminia, 2010). Therefore, can be represented that the pair wise comparison matrix has a consistency index is zero.

For the consistency index (CI) of the  $n$  matrix:

$$CI = \frac{\lambda_{\max} - n}{n - 1}$$

where

CI = consistency index

$\lambda_{\max}$  = the largest eigenvalue of  $n$  matrix

And for consistency ratio is the defined as:

$$CR = \frac{CI}{RI}$$

where

CR = consistency ratio

CI = consistency index

RI = ratio index

Ratio index is the average value of consistency index obtained randomly as shown in table 1. The decision will be consistent if value of a consistency ratio no more than 10%.

Table 2: Value of Ratio Index (RI)

N	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51



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. These criteria are the important considerations used in the selection of construction based on the level of problems.

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.

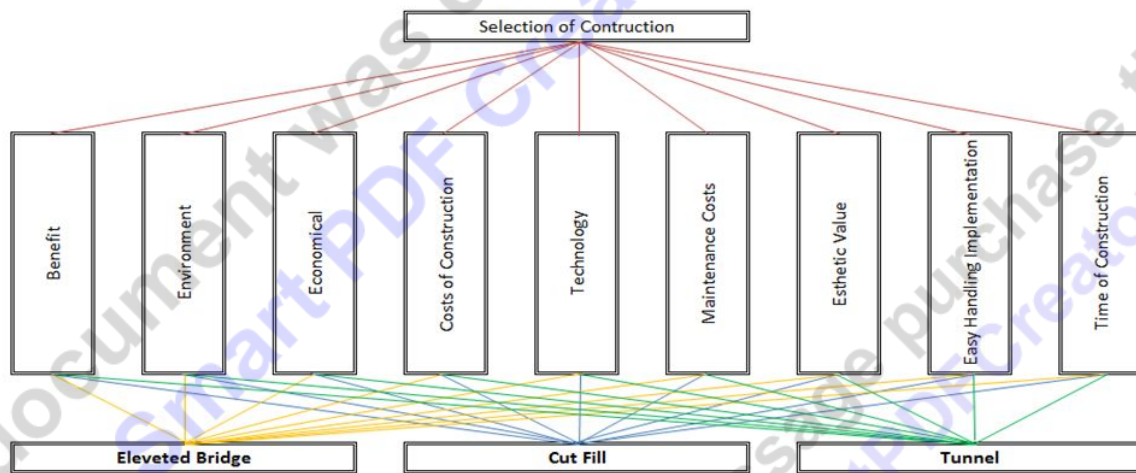


Figure 1: Selection of Alternative Handling Geometric Hierarchy

Analyses were performed using the expert choice version 11.5 where the perception of respondents made pairwise comparison matrices.

### 3.2. CO<sub>2</sub> emissions calculation

Calculate the approximate number of environmental impacts such as CO<sub>2</sub> emissions caused by an alternative construction to using the value of emission factor results 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), Srippl (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.



Table 3: Embodied CO2 Emissions for Construction and Road Activities  
(Kato., et al, 2005; Stipple, 2001; Rajagopalan, 2007; and Rose, 2010)

Type of Construction	Ton CO2/KM			
	Main Construction		Transportation	
	Construction	Maintenance	Construction	Maintenance
Elevated Bridge	3,680	120	0.000045	0.000039
Tunnel	5,310	210		
Cut fill	NA	NA	NA	NA
Asphalt Surface	47.09	10.41	0.000045	0.000039

### 3.3. Efficiency of economic evaluation

The implementation of the policy can work well done proving it theoretically with calculating economic variables through the analysis of the Cost Benefits (CBA) for the best construction to support decision making. This analysis is used for activities that could potentially interfere with the environment and the public interest. The concept is very simple, which measures the value of the benefits and costs of an activity are comparable in size. Activities will lead to the allocation of factors of production more efficient if the value of the benefit is greater than the value of the cost. The Highway Development and Management IV method calculated Vehicle Operating Costs (VOC) based on the preliminary design simulations assuming the current price and geometric parameters. Component of the value of time was calculated by using Integrated Road Management System (IRMS) and the approach of Gross Output (Human Capital Approach) to get the cost of accidents.

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%).

## 4. Case Study

### *Project Descriptions*

Maros-Watampone road 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 145 km with a width average of 6 meters and cross some mountain areas with steep contour's conditions. In

general, cross slope is the more than 17%, horizontal curvature radius is an average of 13 meters, and the critical length is greater than 175 M that can be make slows vehicle speed 4.6 km/h with limited visibility. Every year there is an increase in number of the daily traffic by 7.5%, which led to the higher accident rate of 2.9%. This condition is exacerbated by a geometric path that does not comply with the standards of road construction in Indonesia. As far as 40 km from this road need to repair of geometric conditions to maximize the level of its services. Government can only take action because of road maintenance is constrained by geography and the presence of protected areas of natural habitat in the surrounding streets. This resulted in the road segment had a decrease in the level of service such as regional economic dynamics, comfort and safety of road users.

Since 2007 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-Watampone road. 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.



Figure 2: Existing Geometric Conditions in the Area of Babul National Park

## 5. Analysis Results

### 5.1. 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 4.

Benefits and the environment the top sequence in the selection of criteria for consideration of construction indicated that the type of construction chosen should provide the maximum benefits to society and minimize impact on the environment. The benefits criteria for consideration of being the most contribute people's choice for the construction type because they are aware about the importance of service that will receive from these an activity. The road was built due to the need for the benefit of the road. They prioritize benefits but still considering the effects that will result to the environment so that take of the environmental criteria into the second consideration. People realize that the benefits must be balanced with the impact it would cause to sustain development.

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 4: The Weighting of Criteria and Alternatives

Criteria	Global Weighting	Alternatif Weighting			Inconsistency
		Elevated Bridge	Cutfill	Tunnel	
Benefit	0.300	<b>0.534</b>	<b>0.150</b>	<b>0.316</b>	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	<b>0.08</b>
<b>Priority</b>		<b>1</b>	<b>2</b>	<b>3</b>	

The use of environmentally friendly construction materials greatly affects the sustainability of bio diversity conservation in the surrounding area. The use of alternative materials is needed in an effort to minimize the impact on the environment. If the technology criteria for the next sequence, this shows that the technology should be able to solve geometric problems without ignoring the impact of its use on the environment.

Economic criterion, the cost of construction and maintenance costs, are concerning the use of fund's allocation for construction during the period of the plan. The community does not consider of the construction and maintenance costs that they should spend to build the construction. It shows that they have learned the amount of benefits they will earn and keep the balance of natural requires environment-friendly technology with a great cost in its implementation. These criteria can be calculated in several ways that will be discussed in the next result.

Harmony between construction and the environment need to be considered through aesthetic criteria in order to avoid the impression of a patchwork landscape environment. While the criteria for easy handling and time of implementation tend to have a priority equal weight as both are directly proportional to each other. If construction is not experiencing difficulties in its implementation will mean work time will be faster and as well as the opposite.

Synthesis analysis of weight of criteria and weight of alternative showed that an elevated bridge construction has the highest priority value is 0.528. That's value showed that the construction is the suitable to solve geometric problems on that road. As for the cut and fill (0.428) and tunnel (0.223), each of which occupies the second and third priorities respectively. The results of the sensitivity analysis through expert choice 11.5 can be seen in Figure 3.

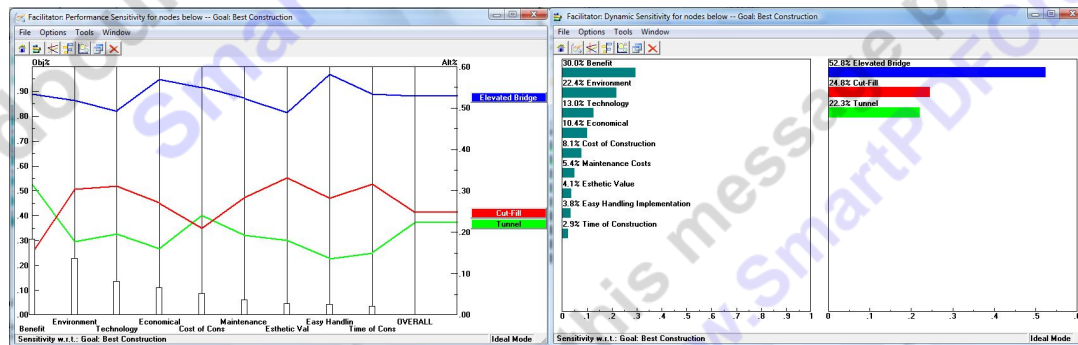


Figure 3: Graph of Sensitivity

All considerations criteria contributed the highest value on the elevated bridge construction. Criteria benefit (0.150) and the construction costs (0.210) gives priority smaller for the cut and fill weights than the tunnel (respectively: 0.316 and 0.240). However, on the other criteria have contributed to an enough weight for the cut and fill construction as the second priority for possible to apply.

Choosing the elevated bridge construction as the most suitable to be applied to Maros-Watampone road is a right decision because the implementation does not change the landscape and has a little effect on the nature. Wildlife habitat will keep maintaining of



sustainability in the conservation area. It assumed that the construction pillar/abutment used as same as with the principle of the high-tension tower of electric can legally traverse some conservation areas. Reach appropriate geometric standards with limited land uses can be made through environmentally friendly technology. However, based on the economic value, the cost of construction and maintenance, require highest costs, needed a special expertise for implementation and considerable time when compared to other types of construction. These criteria are not dominant influence on the value of contribution.

When compared with other types of construction the tunnel and cut-fill both of them have the possibility to destroy the balance of the ecosystem of the road. To get a road grade by 10%, both constructions should be done realignment and extend the trace so that it requires larger land and can damage the rock massif that is widely available around the site. Aesthetic value constructs the elevated bridge superior to apply because it promotes harmony between development and conservation areas that potentially have a high selling value and can eventually increase community incomes.

### 5.2. Application of the Elevated Bridge Construction

The assumptions of an elevated bridge construction design by considering some parameters through the land development program and 3dmax can be seen in Figure 4:



Figure 4: Simulation by the Elevated Bridge Construction

Table 5 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 5: 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

### 5.3. Construction Impacts on CO<sub>2</sub> Emissions

Considering the amount of CO<sub>2</sub> emissions generated by construction activities and transport are need to take into account because these roads are in the conservation area, which is a reserve of oxygen and water supply in the South Sulawesi province. The uses of environmentally construction materials are concerned it can be preserve of the environment sustainability of the areas, in particular, and the region in general.

The study conducted by Horvath (1997), shows that for the construction phase of the bridge has a lower environmental burden, especially in the concrete process. This is similar with our simple calculation by comparing between three type construction where the elevated bridge is the lowest produce CO<sub>2</sub> emissions in its process and operation construction.

Table 6 illustrates that the amount of CO<sub>2</sub> 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<sub>2</sub> emission.

Overall CO<sub>2</sub> emissions resulting from the construction of the elevated bridge (1.31tCO<sub>2</sub>/km) is lower than from tunnel construction (1.79tCO<sub>2</sub>/km). Contribution of CO<sub>2</sub> emissions from the process and maintenance of main construction has a major impact on the value of the total



emissions produced. This is shown in process and maintenance the tunnel construction (1.57tCO<sub>2</sub>/km) has a greater emission than the construction of the elevated bridge (1.08tCO<sub>2</sub>/km). Transport emissions contribute the equivalent value to both types of construction is due to the use of concrete surface in the construction are the same. This is in accordance with the regulations in Indonesia to ban the use of two types of main construction on road construction surface.

The calculation of emissions in existing construction has a lower value because not considering grade road, acceleration and vehicle speed in emission factor evaluation but the emissions produced by asphalt surface only. Therefore, the value contribution of transportation to total emissions in each alternative construction is the same.

Table 6: Estimate the Total Emissions Produced by Each Type of Alternative Construction

Type of Construction	Ton CO <sub>2</sub> /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

#### 5.4. Analysis of the Economic Efficiency

##### 5.4.1. Component of Cost Benefit

Vehicle operating costs was decrease after the implementation of the construction can be seen in Table 7 that shows that the vehicle type truck having a lot of benefits caused by the project. This condition is very supportive of the smooth operation of shipping goods between the south and southeast Sulawesi province which use type of that vehicle. The economic activity of the region will increase as well. Public transport fare reductions (respectively: 938, 537 and 3984) can also be performed due to the large decline in value after the project is operational.

Table 7: 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
Heavy Truck	14,813	8,671	6,142

The private vehicle type sedan/city car user (588) did not receive a big impact so chances are people will switch to using public transport which has decreased tariff. If more people using a public transport that condition will cause a decrease the level of energy consumption and emission be generated by transport activities. Thus, impact on sustainability of environment can be reduced.

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 8: 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

#### 5.5. Feasibility and Sensitivity Analysis of Investment

Table 9 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 9: Sensitivity Test on 25% of Profits and Costs Change

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

## 6. 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, easy for implementation and time of implementation. All criteria have to contribute with significantly in construction process and operation for keep environmental sustainable. Criteria of consideration are 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<sub>2</sub> 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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