

ANALYTIC HIERARCHY PROCESS FOR THE EVALUATION OF TRANSPORT POLICIES IN BANDUNG CITY

Ferry Irawan Kartasasmita^{1*}, Asep Sofyan^{2†}, Bona Frazila^{3†}, dan I Made Bayu^{4†}

Master Programme for Environmental Engineering

Faculty of Civil and Environmental Engineering, Institut Teknologi Bandung

Jl Ganesha 10 Bandung 40132

Email: ferryirawank@gmail.com¹, asepsofyan@gmail.com², frazila@yahoo.com³, imadebayuitb@gmail.com⁴

* Presenter; † Corresponding author.

Abstract: Increased of amounts vehicles in every year can be problems toward transportation governance of Bandung city. The congestion and increased air pollution into special consideration determining the direction of transportation policy in this city. Hence the need for a study that aims to fill these knowledge gaps in the transport sector. This research will be involved with the environment, transportation and other policies relevant to assessing transportation options with multiple criteria such as affordability, implementability, transport quality and quantity of services and environmental sustainability as well. The Analytic Hierarchy Process (AHP) is a method of measurement for formulating and analyzing decisions. It is decision tool support which can be used to solved complex decision problems into account tangible and intangible aspects. in this research uses data was collected through a questionnaire which was divided into four stakeholders, namely; Government, academia, private sector workers and the local community. AHP provides convenience in determining priority criteria for the transportation plan. The result of this research showed that the most of respondents consists of local government, academia, private sector workers, and the local community perceive that sustainable of environmental is a major priority in terms of the criteria determining the transportation plan with a percentage of 28.87%. The quality of transportation services, affordability economically, ease to be implamented and the quantity of transport service were in the range of 21,78% ; 20,17% ; 19,77 % ; 9,39 %, respectively.

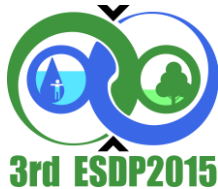
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INTRODUCTION

Bandung is the capital of West Java province. Has an area of 167.7 km², Bandung role as a center of social, economic, and governance. As a consequence that carried the function city, this affects the municipality experiencing a many problems.

One important problem is the transportation. Increasing the amount of motor vehicles occur each year, until in 2014 the amount of motor vehicles be 1,539,409. As the details, the amount of motorcycles is 1,113,316. Passenger cars also increased to 351 650. But it is not accompanied by the addition of roads. Therefore to ensure smooth traffic, coupled with the increasing air pollution due to vehicle exhaust in Bandung, it needs a good transportation planning. Many cities in Asia Possess significant potential to reduce both of air pollution and mitigate climate change with a single policy or plan. The air quality and climate change benefits from the single policy or plan are known as co-benefits. Urban policymakers often lack knowledge over which action can deliver the greatest co-benefits.

This study aims to fill these knowledge gaps in the transport sector. Researchers will engage with environmental, transport and other relevant policymakers to assesss the same



transport options along several criteria (affordability, implementability, transport service quality and quantity and also environmental sustainability).

The aim of the different plans to reduce the greenhouse gas emissions and, hence, the adverse climate change impacts, can usually be achieved by different transport policies, each characterized by quantitatively and qualitatively different effects on the transportation system itself, as well as on the natural environment and economic and social context.

In order to choose the optimal policy action to reduce the adverse climate change impacts due to the transport sector, we have applied the analytic hierarchy process (AHP), developed by Saaty (1980), which decomposes the decisional process in a hierarchy of criteria, subcriteria, attributes and alternatives through a set of weights that reflect the relative importance of alternatives. The AHP has become a significant methodology in EIA due to its capability for facilitating multi-criteria decision-making (Ramanathan, 2001).

Tracz and Wawrzynekiewicz (1993) used AHP in the selection of public transport system alternatives. Khasnabis and Chaudry (1994), based on their application of AHP to evaluate transit privatisation projects in Detroit metropolitan area, found that AHP is feasible tool for priority ranking of transportation projects. Tabucanon and Lee (1995), in their study of evaluation of rural highway improvement projects in Korea, concluded that the application of AHP gave more balanced outcomes for various conflicting criteria compared to traditional economic evaluation method.

RESEARCH METHOD

Data Collection

Collecting data through questionnaires which were divided into four stakeholders, namely; The local government, academia, private sector workers and local community. And then, the amount of questionnaires distributed 10 pieces for each stakeholder, so that the end result will be collected 40 questionnaires. Distribution of questionnaires in local government, represented by the instance related to the environment, transport, industry, and other relevant instances. Selection of the field of local government in order to know the thoughts and views of stakeholders in Bandung City.

Selection of respondents in the field of academics refer to the lecturer and students related to their field of environment and transport. So expect the choice of academic experts can give a thought to the transportation conditions through scientific and theoretical in Bandung City. While the selection of private sector workers and the public is aimed at knowing the views and desires of users of transport policy that every day feel the road conditions in Bandung City.

Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a method of measurement for formulating and analyzing decisions. Saaty (1980) provided a theoretical foundation for the AHP, that is a decision support tool which can be used to solve complex decision problems taking into account tangible and intangible aspects. Therefore, it supports decision makers to make decisions

involving their experience, knowledge and intuition.

The AHP decomposes the decision problem into elements, according to their common characteristics, and levels, which correspond to the common characteristic of the elements. The topmost level is the “focus” of the problem or ultimate goal; the intermediate levels correspond to criteria and sub-criteria, while the lowest level contains the “decision alternatives”. If each element of each level depends on all the elements of the upper level, then the hierarchy is complete; otherwise, it is defined incomplete. The elements of each level are compared pairwise with respect to a specific element in the immediate upper level.

To make a decision in an organised way to generate priorities we need to decompose the decision into the following steps.

- a. Define the problem and determine the kind of knowledge sought.
- b. Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).
- c. Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.
- d. Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level are obtained.

Table 1 reports the pairwise comparison scale used in the AHP developed by Saaty (2008). It allows to convert the qualitative judgments into a numerical values, also with intangible attributes.

For computing the priorities of the elements, a judgmental matrix is assumed as follows:

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} \quad (1)$$

where a_{ij} represents the pairwise comparison rating between the element i and element j of a level with respect to the upper level. The entries a_{ij} are governed by the following rules: $a_{ij} > 0$; $a_{ij} = 1/a_{ji}$; $a_{ii} = 1 \forall i$.

Following Saaty (1980, 2000), the priorities of the elements can be estimated by finding the principal eigenvector w of the matrix A , that is:

$$AW = \lambda_{\max} W \quad (2)$$

When the vector W is normalized, it becomes the vector of priorities of elements of one level with respect to the upper level. λ_{\max} is the largest eigenvalue of the matrix A . In cases



where the pairwise comparison matrix satisfies transitivity for all pairwise comparisons it is said to be consistent and it verifies the following relation :

$$a_{ij} = a_{ik}a_{kj} \quad \forall i,j,k \quad (3)$$

Table 1. The AHP Pairwise Comparison Scale

Numerical Values	Verbal Scale	Explanation
1	Equal importance of both elements	Two activities contribute equally to the objective
2	Slightly more important	
3	Moderately more important	Experience and judgement slightly favour one activity over another
4	Much more important	Experience and judgement strongly favour one activity over another
5	Significantly more important	The evidence favouring one activity over another is of the highest possible order of affirmation

Source: Satty (2008)

Saaty (1980) has shown that to maintain reasonable consistency when deriving priorities from paired comparisons, the number of factors being considered must be less or equal to nine. AHP allows inconsistency, but provides a measure of the inconsistency in each set of judgments. The consistency of the judgmental matrix can be determined by a measure called the consistency ratio (CR), defined as:

$$CR = \frac{CI}{RI} \quad (4)$$

where CI is called the consistency index and RI is the Random Index. Furthermore, Saaty (1980, 2000) provided average consistencies (RI values) of randomly generated matrices (table 2). CI for a matrix of order n is defined as:

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (5)$$

In general, a consistency ratio of 0.1 or less is considered acceptable, this threshold is 0.08 for matrices of size four and 1.11 for matrices of size five.

Table 2. The Average Consistencies Of Random Matrices (RI Values)

Size	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Assessment of Alternative Transport Policies

In order to evaluate alternative transport policies to reduce the adverse climate change impacts. Finally, the authors develop the structure in two different levels; Level 1 is the criteria and the last level represents the alternatives of transportation policy. At level 1 calculation using the analytic hierarchy process (AHP). A determination of priorities of the five criteria that we proposed, namely Quantity and Quality Transport Service, Affordable, implementable, and Environmentally Sustainable. Meanwhile, at level 2, calculating the weighted value based on the rankings obtained from each of the policy alternatives.

We have asked the opinion of 40 people from various stakeholders and asked to rank them in order set 11 alternative transportation policy. This ranking assessment aims to make a judgment in the determination of alternative transport policy. Rank 1 is an alternative policy to get the top value or is the primary and essential. Meanwhile, if you get the latest rankings, it is the weakest policy alternatives or unimportant.

Where the weighting value is based on the reverse of the ranking obtained from the policy. For example, if a policy gets rank 1 then the policy will get the score of 11, if the rank 2 will get a score of 10, and if the policy is to get the last rank, 11, it will get the score 1.

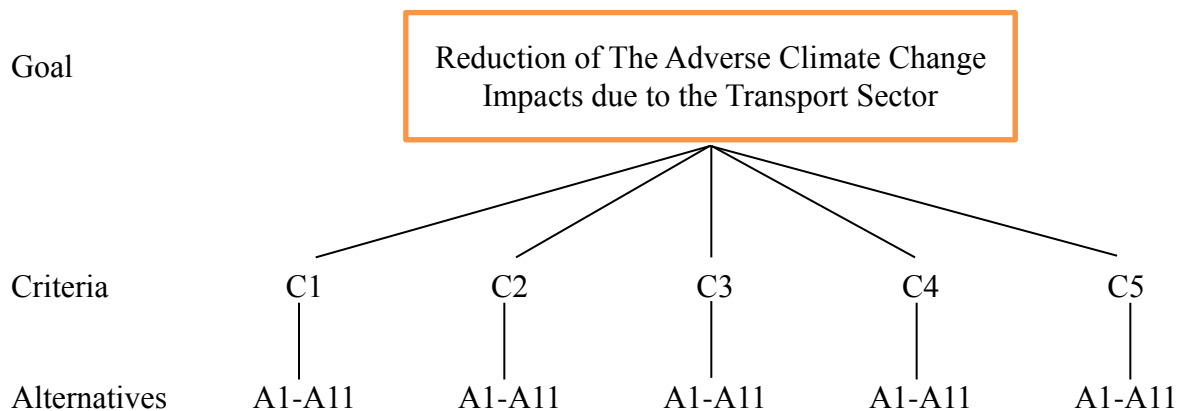
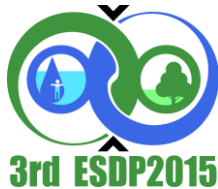


Figure 1. Analytic Hierarchy Structure

Where:

C1 Quantity Transport Service
 C2 Quality Transport Service

A1 School Zoning
 A2 Pedestrian Facilities
 A3 Work Scheduling



C3 Affordable
 C4 Implementable
 C5 Environmentally Sustainable

A4 BRT (Bus Rapid Transit) System
 A5 Revitalization of Angkot
 A6 Car Free Day in Certain Road
 A7 School Bus
 A8 Promoting LRT/MRT
 A9 Eco Driving
 A10 I/M Program
 A11 ATCS System

RESULT AND DISCUSSION

By applying the procedure previously outlined, the results indicate the highest importance to the criteria C5 “Environmentally Sustainable” (28.87%); This indicates that all stakeholders want a transportation system that relies on environmental sustainability. so that at the current state of the stakeholders have had a future mind to keep the earth from environmental damage as a result of pollution generated by vehicle exhaust.

The second condition and the third is chosen C2 and C3 “Quality and affordability of transport services” with a score of 21.78% and 20.17% is an fact that all stakeholders after the program environmental sustainability also want the convenience and low prices for using transport services.

The last option on the quantity of transport services stated that all stakeholders do not expect much to have the addition of transport services in the city of Bandung. They prioritize environmental sustainability, quality and affordability economically to repair the current transportation services

As results from the eigen vector of the comparison matrix criteria, reported in table 3, whose components provide an estimate of the weights of the criteria. The principal eigen value of this matrix is $\lambda_{max} = 5.052$, with a consistency ratio $CR = 0.01 < 0.1$. Thus, the results are consistent.

Table 3. Comparison of Matrix Criteria

Criteria	C1	C2	C3	C4	C5	Weight vector	Percentage (%)
C1	1.000	0.377	0.395	0.432	0.457	0.0939	9.397
C2	2.653	1.000	0.964	1.117	0.753	0.2178	21.780
C3	2.532	1.037	1.000	0.883	0.620	0.2017	20.170
C4	2.315	0.895	1.132	1.000	0.562	0.1977	19.778
C5	2.188	1.328	1.614	1.781	1.000	0.2887	28.875

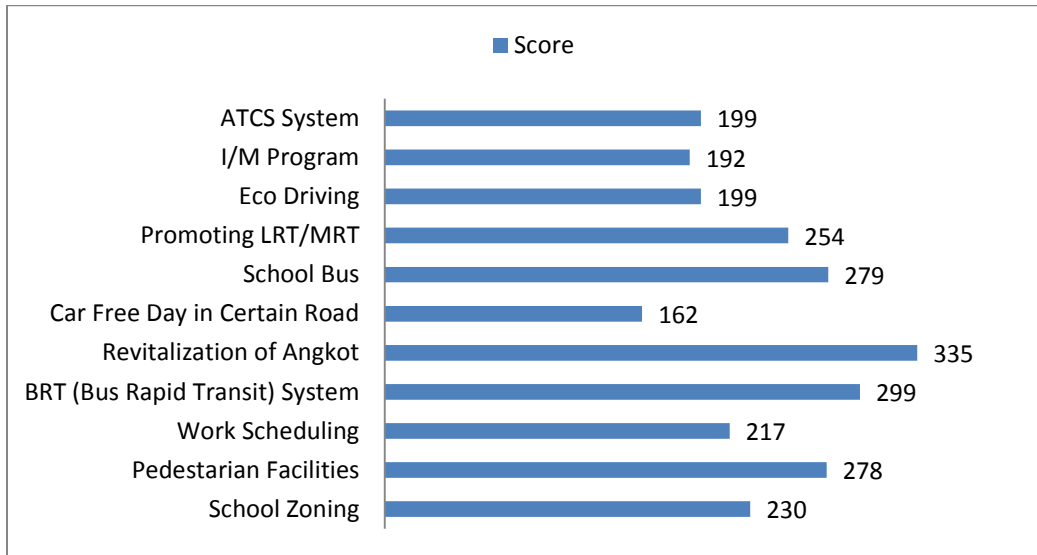


Figure 2. Comparison of Quality Transport Services

This study about the quality of transportation services, all stakeholders who filled out a questionnaire considers the revitalization of public transportation (Angkot) is a top priority to improving the quality of transportation services. As known, Angkot is the dominant mode of public transport that are used in Bandung city, and the unavailability of bus rapid transit and the LRT or MRT also. Thus revitalizing angkot becomes expected to begin immediately.

The second option is the presence of a bus rapid transit as neighboring cities, namely Jakarta. All stakeholders would want a mode of transportation that is fast, has a special line and able to accommodate more passengers. So that BRT is expected to answer the wishes of the citizens of Bandung to improve the quality of transportation services. Together with other kebijakan policies that have high scores, such as the presence of a school bus and pedestrian facility improvements.

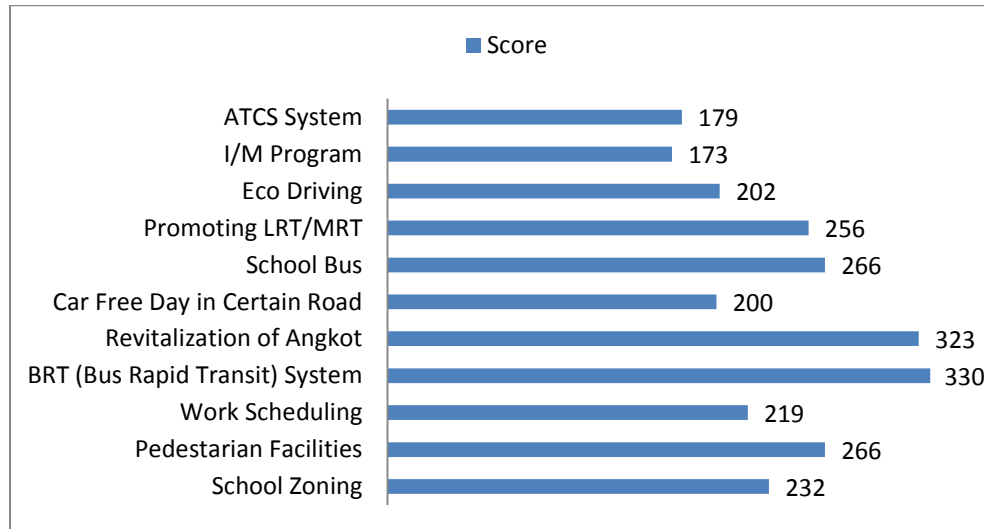


Figure 3. Comparison of Quantity Transport Services

The quantity of transport services do have the lowest percentage in the assessment criteria for the transportation program. But all stakeholders remain hopeful increase in the quantity of transport services by presenting a bus rapid transit as a priority. it is understood the public, BRT can accommodate many passengers so that they can answer the problem of the quantity of transport services. Besides that, the next priority is the revitalization of angkot, school bus and pedestrian facilities in succession in order to increase the quantity of transport services.

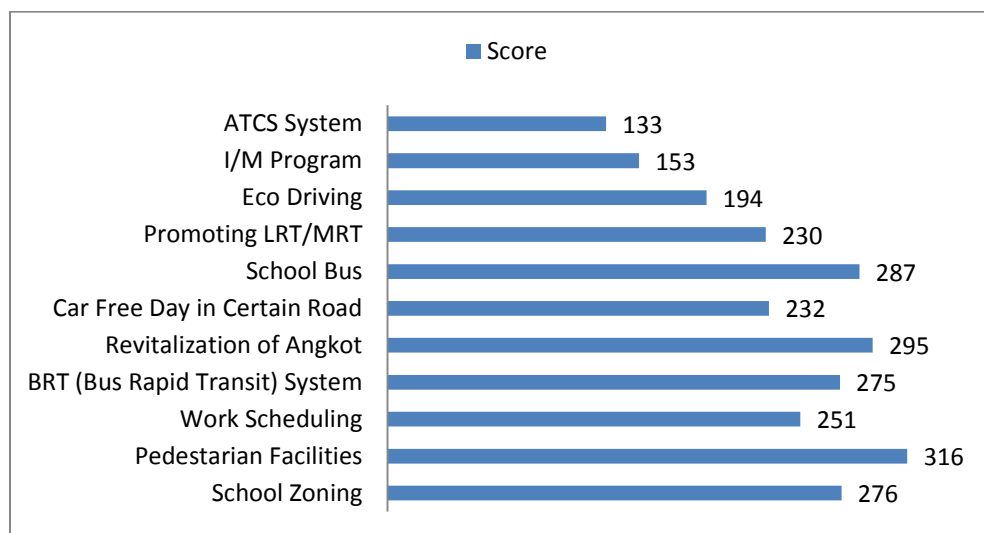


Figure 4. Comparison of Affordability Economically

Transportation services are always associated with economic aspects. Thus the economic affordability is also a criterion in the development of transportation services. The majority of stakeholders considers the repair and manufacture of pedestrian facilities is the main priority is first implemented when talking about the economic aspects of society.

The second option, the revitalization of angkot be expected in the provision of affordable transport services economically. It should also be noted policy of providing school bus and school zoning which also has a high score chosen by stakeholders.

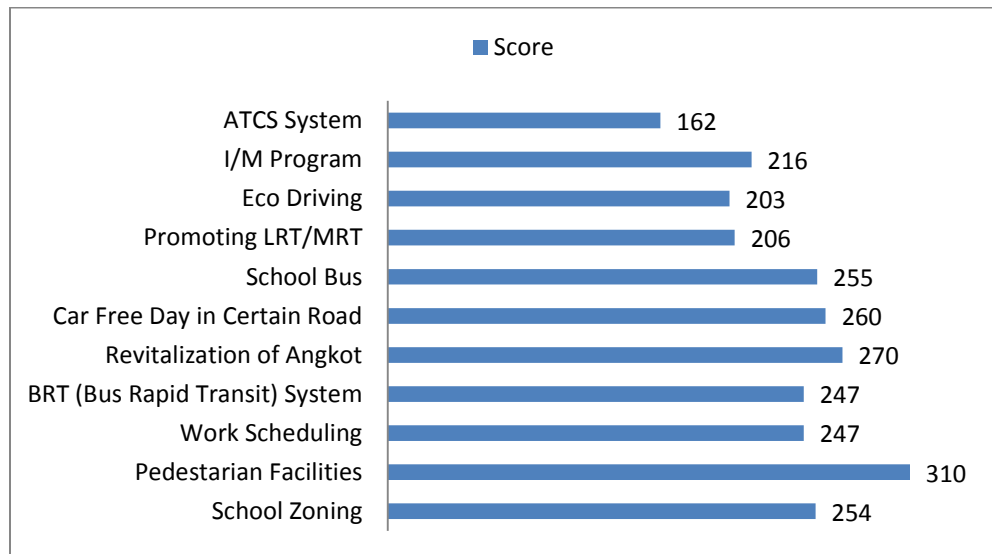


Figure 5. Comparison of Implementable

Ease of implementation is essential in improving transportation services. Majority stakeholder of course able to get the all the policies that have been planned to be realized quickly. Program policies are a top priority of the respondents is the repair and manufacture of pedestrian facilities. It is considered the easiest to implement.

The second option is the revitalization of public transportation, which is returned to the expectations of citizens Bandung because it is easy in the implementation phase. Another option with the holding car free day and the procurement of school buses.

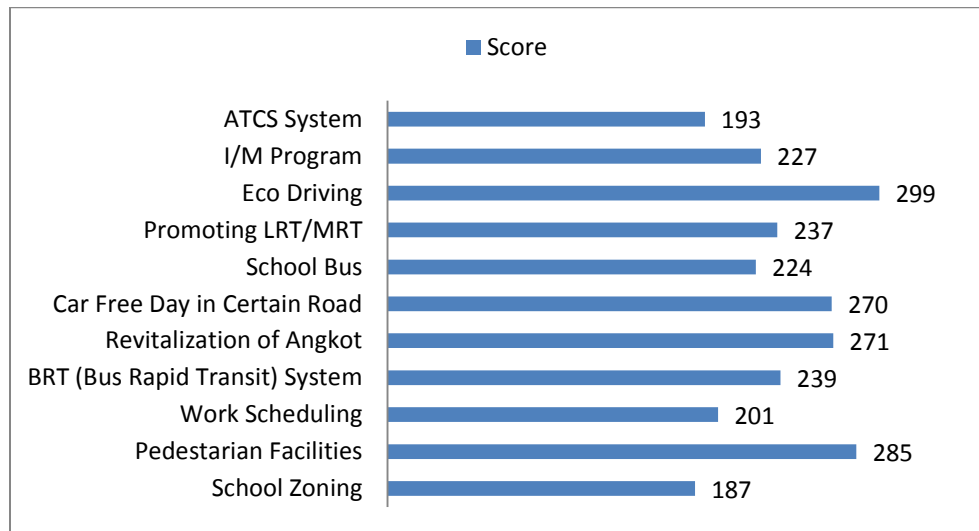


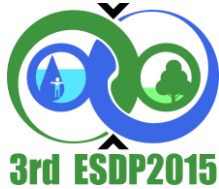
Figure 6. Comparison of Environmentally Sustainable

Transportation services that support environmental sustainability, the majority stakeholder choose eco driving is the best policy, as it seeks to change people's behavior in terms of driving the vehicle and attempted in an effort to fuel savings in ways that can improve fuel efficiency of spending. The second option is to repair and manufacture of pedestrian facilities, so that citizens of the city of Bandung more comfortable traveling by foot, become Bandung as an environmentally friendly city.

CONCLUSION AND SUGGESTION

In this study, AHP provides convenience in determining priority criteria for the transportation plan. With the result that the majority of respondents consists of local government, academia, private sector workers, and the public perceive that environmentally sustainable is a major priority in terms of the criteria determining the transportation plan with a percentage of 28.87%. Followed by the quality of transportation services amounted to 21.78%, Affordability economically by 20.17%. Ease to be implemented by 19.77% and the quantity of transport services by 9.39%.

In the determination of policy alternatives that a total of 11 choices. On the criteria of the quality of transportation services a major priority in the revitalization of public transportation. On the criteria of quantity of transport services a top priority in the implementation of a neat bus transit (BRT). On the criteria of economic affordability of the majority of respondents prioritize pedestrian facilities. Implemented on the criteria of convenience is a top priority pedestrian facilities. And environmental sustainability criteria for prioritizing eco driving the majority of respondents as the best solution in an effort to maintain the environmental quality of the transport sector.



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