

# Determining of Environmental Laboratory Locations Using Analytical Hierarchy Process Method in West Java Province

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## ABSTRACT

*The province of West Java is one of the largest industrial areas in Indonesia. But there are threats that could disrupt industrial activity in West Java, one of the threats to environmental quality. An important factor influencing the effectiveness and efficiency of environmental management in the area is whether or not a laboratory exists. UP Ltd. is an environmental laboratory services company established since 1990 and located in South Jakarta. Looking at the state of West Java, the company is interested in developing its business by opening a branch in West Java Province. Opening a new branch location or location factor is an important factor. Therefore, this study is a study of branch office location using Analytical Hierarchy Process method approach as a decision support system to determine alternative locations according to the criteria and sub-criteria set by the company. Data processing result using AHP that Location 03 has the biggest weight with a value of 0,53840. Location 02's second order with a value of 0,25719, and an alternative location who has the lowest weight Location 01 value of 0,20103.*

**Key Words:** Analytical Hierarchy Process, Environmental Laboratory, Cost, Location, Facilities

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## 1. INTRODUCTION

The province of West Java is one of the largest industrial areas in Indonesia. As of 2014, there were 6633 industries in West Java Province, an increase of 2.73% from 2013 amounting to 6457 industries [1]. Kadin chairman Agung Suryamai Sutisno in Bandung said that the province of West Java was still the center of the national industry as it controlled more than 50 percent of the industrial sector's contribution to the national economy. Thanks to the industrial sector also made West Java the third largest contributor to Gross Domestic Product (GDP) by 14.07 percent after Jakarta at 16.40 percent and East Java at 14.88 percent [2].

Industry tends to have a positive impact on social life, but it has many negative effects on the environment such as water pollution, air pollution and so on [3]. An important aspect that can affect the effectiveness and efficiency of environmental management in a country or region is the availability of laboratories that are capable of producing valid, reliable, indisputable, and scientific data [4]. According to data from the Ministry of Environment and Forestry [5], the availability of environmental laboratories in West Java is only 26 laboratories. This number is certainly not comparable to the number of industries in West Java reaching more than 6000 industries.

UP Ltd. is an environmental laboratory services company established in 1990 and located in South Jakarta. Serving sectors include the industrial, mining, plantation, oil, power generation, hospital and developer sectors with unlimited service areas in Jakarta. In view of this, the business development division of the company plans to open an environmental laboratory branch in West Java with the hope of competing in providing environmental testing services and increasing the company's revenue.

To be more effective in business development by opening up a new branch of business, location selection research is one of the many ways in which it can be used [6]. Based on research [7], COG coordinates were found in Mulyasejati, Ciampel, Karawang Regency, West Java. Therefore this study aims to continue the previous research which is to determine the location of the branch

office using the Analytical Hierarchy Process method as a decision support system to determine alternative locations according to the criteria and sub-criteria set by the company.

## **2. LITERATURE REVIEW**

UP Ltd. is a company that offers specialized services in the field of environment to all its clients from industry, hospital, and government, to achieve a clean, comfortable, and sustainable environment. Services and products provided include sampling and analysis of water, biological, air, chimney discharge, vehicle emission, sediment /sludge.

Analytical Hierarchy Process (AHP) was developed by Thomas L. Saaty in the 1988. When several criteria must be considered, AHP is one of many methods that will help to prioritize several alternatives. It also constructs complex problems into a hierarchy for the decision makers. AHP is used for problems solving in terms of planning, alternative determination, prioritization, policy selection, resource allocation, needs determination, results in forecasting, outcome planning, system planning, performance measurement, optimization, and conflict resolution [8]. There are 4 Basic principles in the AHP methodology for decision-making, namely: Decomposition, Comparative Judgement, Synthesis of Priority and Logical Consistency. In using those four principles, AHP brings together two aspects of decision making:

- a. Qualitatively, the AHP identify and the problems and assessments, in order to find the problem solutions, and
- b. Quantitatively, the AHP performs numerical comparisons and assessments in order to find the problem solutions.

One of the most frequently used methods in decision support systems is AHP, various decision support systems have been widely used in the industrial world, essentially referring to the evaluation of multiple criteria, to evaluate some of the existing criteria using the AHP method that can approach qualitative and quantitative criteria assessment quantitative [9]. The AHP method is an excellent Multi-Criteria Decision Making (MCDM) method for modeling expert opinion in decision support systems [10]. AHPs are particularly concerned about deviations from consistency, measurement, and dependence within and between groups of structural elements [11].

AHP method enables the use of more flexible and inclusive information about alternative locations in determining location of facilities [12]. In determining the location of AHP method facilities, [13] with six criteria which are Cost, Competence of the service, location, closeness to COG, Logistical Factor, and Cultural cost. Determining location using AHP is not only consider the cost and distance of transport, but also consider the physical condition, social environment and economic situation [14]. AHP helps companies choose the best location so they can build new factories and grow their operations using criteria for real estate prices, distance from suppliers, quality of labor, and labor costs [15].

## **3. METHODOLOGY**

AHP method requires assessment using expert respondents (experts), therefore this study chose a respondent who is considered an expert in determining location for environmental laboratory. What is meant by expert respondents here are people who are experienced in environmental laboratory, one of which is in the business development division. In the selection criteria and sub-criteria for this model, data collection and processing are done in 2 stages:

1. The collection of criteria that will be given to respondents is collected based on several previous research references. Then the selection of criteria and sub-criteria is carried out through interviews in determining the appropriate criteria and sub-criteria in determining location for environmental laboratory.
2. Weighting the tire supplier evaluation criteria and sub-criteria according to respondents through a questionnaire which is then asked to give weight to the criteria with the basis of pairwise comparison [16].

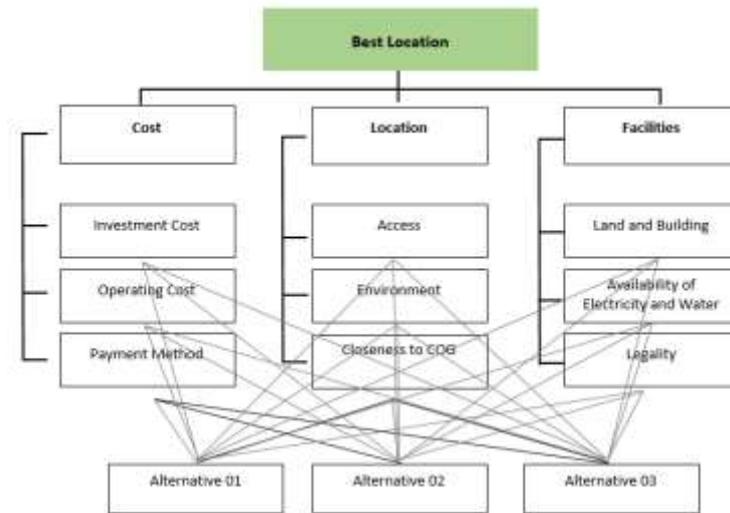


Figure 1. Decision Hierarchical Structure

The data processing stage is done by summing the weight given by the respondents to the criteria and sub-criteria according to the basic pairwise comparison scale [16]. The following are the criteria selected by the respondents in determining the weight of criteria to evaluate supplier performance. And then data processing is carried out in 2 stages:

1. Processing data from respondents using Excel, with assessments obtained from respondents for each criterion.
2. Calculate the weight which is a priority for each criterion and the inconsistency ratio using Excel.

The comparison matrix of criteria for respondents is input for processing data using Excel. The results of data processing using Excel are the weights and priorities of each criterion and the inconsistency ratio of each pairwise comparison matrix.

## 4. RESULT AND DISCUSSION

### 4.1 Hierarchy Structure Determination

This study uses the AHP method to measure supplier performance, for the tire supplier category in third party logistics companies. As for measuring supplier performance, there are certain criteria. The AHP method has 4 levels, the first level is to selection location, the second level is the criteria, the third level is subcriteria, the fourth level is the alternative supplier. The first stage in this study is determining criteria through literature studies. The second stage is interview with respondents who are experts in its field. After determining the criteria and the subcriteria, a questionnaire was made to assess the level of importance of each of these criteria.

#### 4.2. Criteria Weighting and Consistency Test

Based on the results of the questionnaire data processing, it is known that the priority weights of each criterion will be analyzed in this chapter. This questionnaire was filled in by the experts, then the results of the questionnaire were tested for consistency on all criteria. Test consistency on the criteria shows that this questionnaire is filled consistently. After the consistency test gives consistent results, so the weighting process can be carried out for suppliers, the results of which can be seen in Figure 1.

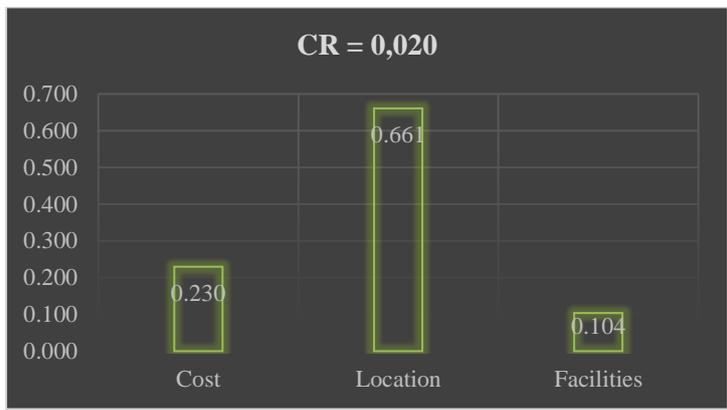


Figure 2. Weight and Ratio of Criteria Inconsistency

In Figure 1 it can be seen that location is the most important thing, because it has the highest value of 0,661. Because that location really determines whether the company's facilities are effective or not. Cost become the second priority with a value of 0,230, then followed by facilities with a value of 0.104.

**4.3. Sub-criteria Cost Weighting and Consistency Test**

After analyzing the priority weights of the criteria, the following will be analyzed the sub-criteria on the cost criteria as shown in Figure 2 below.

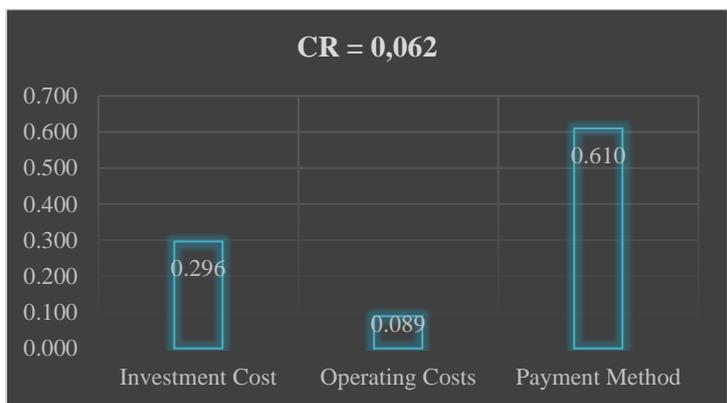


Figure 3. Weight and Ratio of Sub-criteria Cost Inconsistency

In Figure 2 it can be seen that payment method is the most important thing, because it has the highest value of 0,610. Because metode pembayaran akan memudahkan perusahaan dalam pengelolaan keuangan. Investment cost become the second priority with a value of 0,296, then followed by operating cost with a value of 0,089.

**4.4. Sub-criteria Location Weighting and Consistency Test**

After analyzing the priority weight of the criteria, the following will be analyzed by the sub-criteria on the location criteria as shown in Figure 3 below.

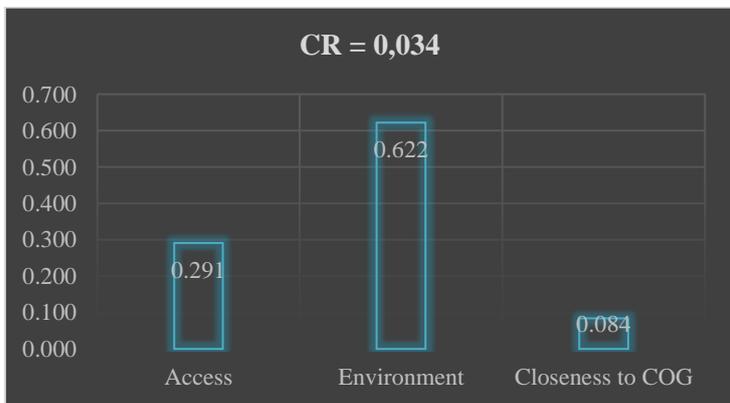


Figure 4. Weight and Ratio of Sub-criteria Location Inconsistency

In Figure 3 it can be seen that environment is the most important thing, because it has the highest value of 0,622. Because the environment affects the operations of the company. Access become the second priority with a value of 0,291, then followed by facilities with a value of 0.084.

#### 4.5. Sub-criteria Facilities Weighting and Consistency Test

After analyzing the priority weight of the sub-criteria, the following will be analyzed sub-criteria on the facilities sub-criteria as shown in Figure 4 below.

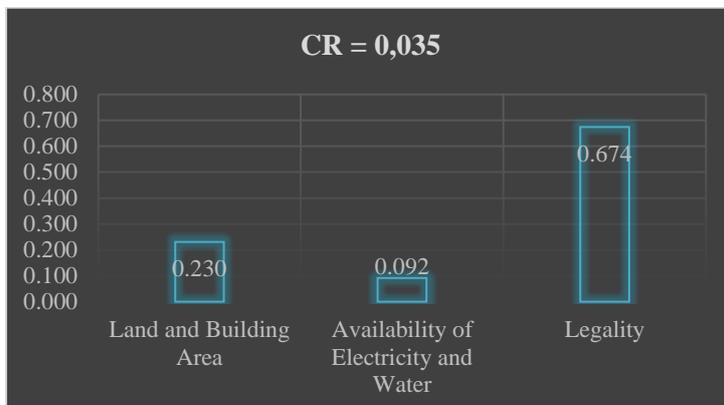


Figure 5. Weight and Ratio of Sub-criteria Facilities Inconsistency

In Figure 4 it can be seen that legality the most important thing, because it has the highest value of 0,674. Because legality is the legal basis for the ownership of the facility. Land and building area become the second priority with a value of 0,230, then followed by availability of electricity and water with a value of 0.092.

#### 4.6. Consistency Test and Location Weighting on Investment Cost

After analyzing the priority weight of the sub-criteria, the following will be analyzed the location priority weighting on the investment cost sub-criteria as shown in Figure 5 below.

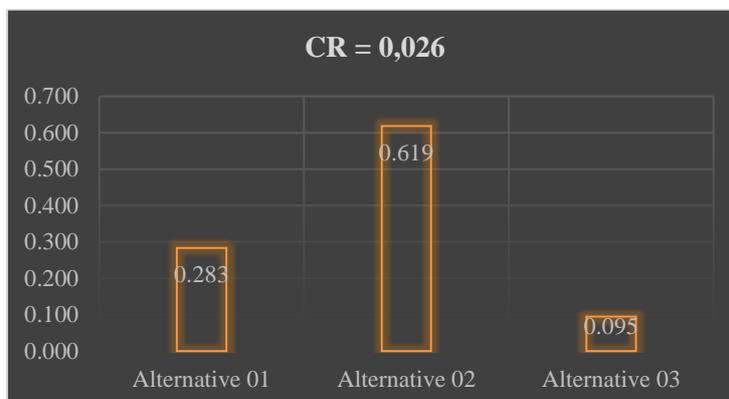


Figure 6. Alternative Locations Weight on Investment Cost Sub-criteria

The supplier who has the highest value for the best investment cost sub-criteria is location 02 with a value of 0,619, this shows that Location 02 is the alternative with the best in investment cost. Location 01 has a value of 0,283, second. For the third order of this sub-criterion is location 03 with a value of 0.095.

#### 4.7. Consistency Test and Location Weighting on Operating Cost

After analyzing the priority weights of the sub-criteria, the following will be analyzed the location priority weighting on the operating cost sub-criteria as shown in Figure 6 below.

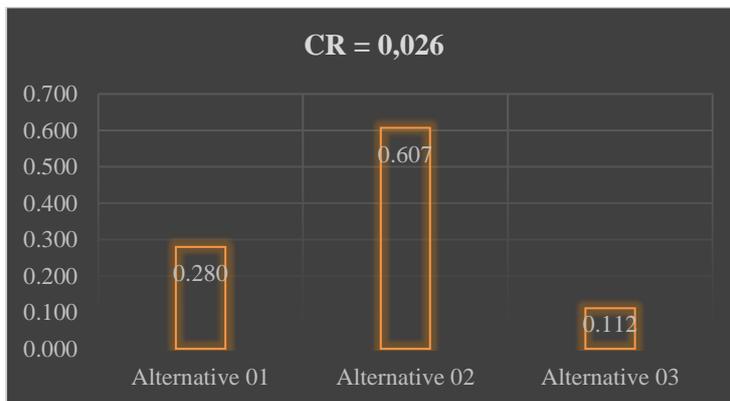


Figure 7. Alternative Locations Weight on Operating Cost Sub-criteria

Location who have the highest value for operating cost sub-criteria are location 02 with a value of 0.607, followed by location 01 with a value of 0,280, and finally location 03 with a value of 0,112. Location 02 has the highest weight since it does not require high operating costs to use the facility.

**4.8. Consistency Test and Location Weighting on Payment Method**

After analyzing the priority weight of the sub-criteria, the following will be analyzed by the location priority weight on the payment method sub-criteria as shown in Figure 7 below.

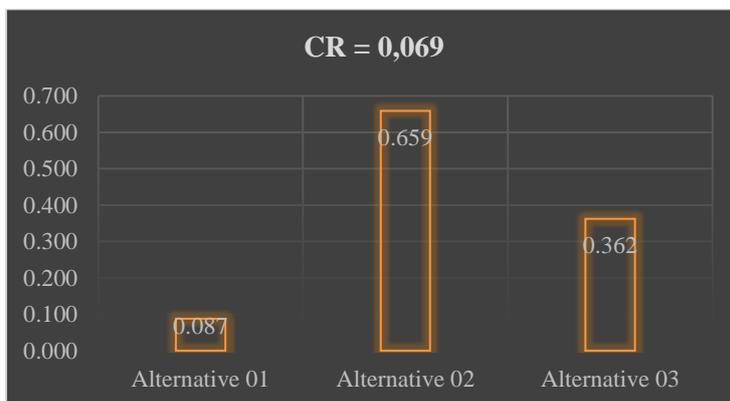


Figure 8. Alternative Locations Weight on Payment Method Sub-criteria

Location who has the highest value for the payment method sub-criteria is location 02 with a value of 0,659 this indicates that location 2 is an alternative to the simplest payment method. The second position was location 03 with a value of 0,362, then location 01 with a weight of 0,087.

**4.9. Consistency Test and Location Weighting on Access**

After analyzing the priority weight of the sub-criteria, the following will be analyzed the location priority weights on access sub-criteria as shown in Figure 8 below.

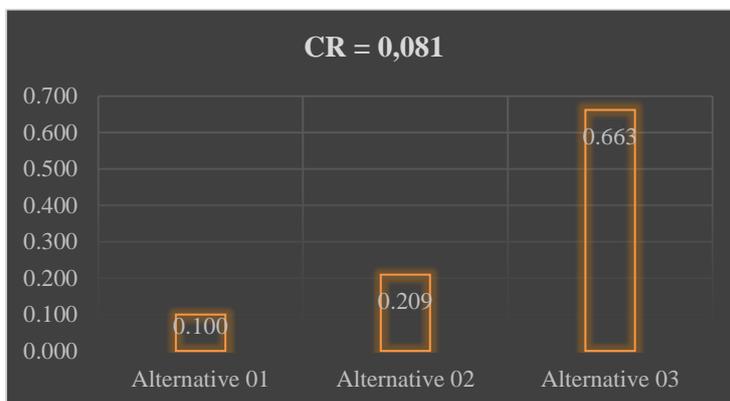
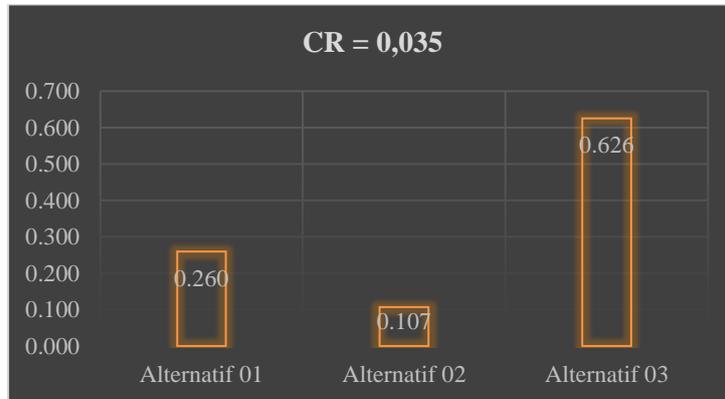


Figure 9. Alternative Locations Weight on Access Sub-riteria

Location who has the highest value for the access sub-criteria is location 03 with a weight of 0,663, this indicates that location 03 is the best alternative to access. Second placed location 02 with a value of 0,209, and finally location 01 with a value of 0.100.

**4.10. Consistency Test and Location Weighting on Environment**

After analyzing the priority weight of the sub-criteria, the following will be analyzed the location priority weighting on the environment sub-criteria as shown in Figure 9 below.

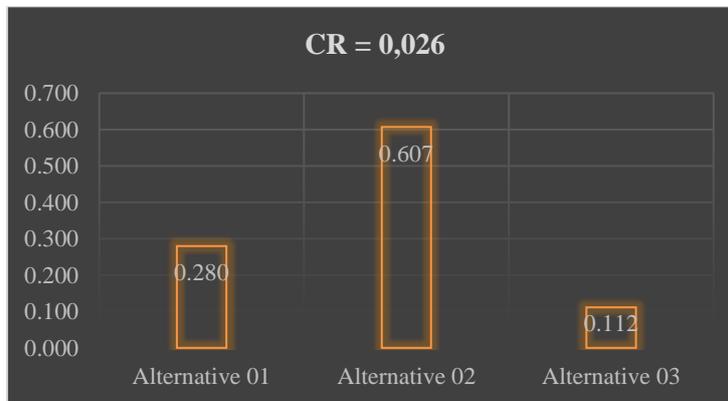


**Figure 10. Alternative Locations Weight on Environment Sub-criteria**

The supplier who has the highest value for the best environment sub-criteria is location 03 with a value of 0,626, , this indicates that Location 03 is a low-risk alternative. Location 01 has a value of 0,260, second. Then the third order of this sub-criterion is location 02 with a value of 0,107.

**4.11. Consistency Test and Location Weighting on Closeness to COG**

After analyzing the priority weights of the sub-criteria, the following will be analyzed the location priority weighting on the closeness to COG sub-criteria as shown in Figure 10 below.



**Figure 11. Alternative Locations Weight on Closeness to COG Sub-criteria**

Locations who have the highest value for closeness to COG sub-criteria are location 02 with a value of 0.607, followed by location 01 with a value of 0,280, and finally location 03 with a value of 0,280. Location 02 has the greatest weight since it is close to the COG coordinates.

**4.12. Consistency Test and Location Weighting on Land and Building Area**

After analyzing the priority weight of the sub-criteria, the following will be analyzed by the location priority weight on the land and building rea sub-criteria as shown in Figure 11 below.

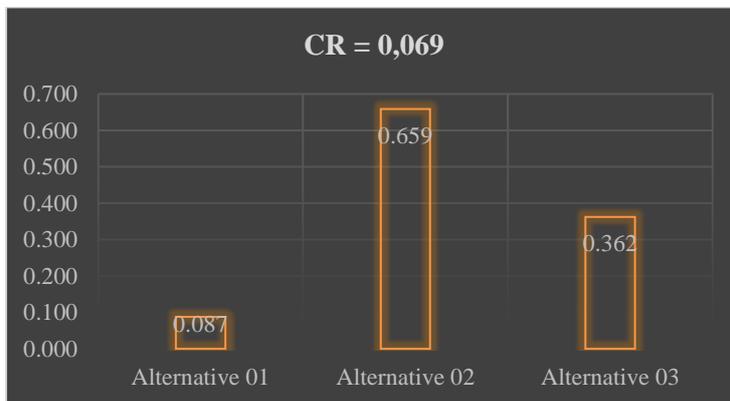


Figure 12. Alternative Locations Weight on Land and Building Area Sub-criteria

The location who has the highest value for the land and building area sub-criteria is location 02 with a value of 0,659, this shows that location 02 is the biggest alternative with weight on land and building area. The second position was location 03 with a value of 0,362, then location 01 with a weight of 0.087.

**4.13. Consistency Test and Location Weighting on Availability of Electricity and Water**

After analyzing the priority weight of the sub-criteria, the following will be analyzed the location priority weights on the availability of electricity and water sub-criteria as shown in Figure 12 below.

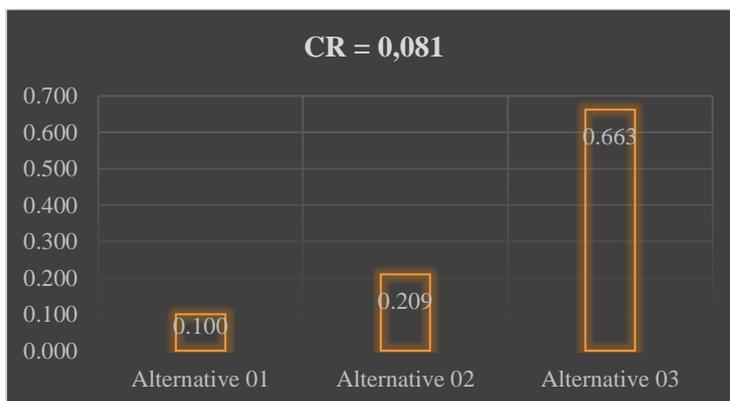


Figure 13. Alternative Locations Weight on Availability of Electricity and Water Sub-criteria

The location who has the highest value for the availability of electricity and water sub-criteria is location 03 with a weight of 0,663, this indicates that location 03 has electricity and water availability according to the company. Second placed location 02 with a value of 0,209, and finally location 01 with a value of 0,100.

**4.14. Consistency Test and Location Weighting on Legality**

After analyzing the priority weight of the sub-criteria, the following will be analyzed the location priority weighting on the legality sub-criteria as shown in Figure 13 below.

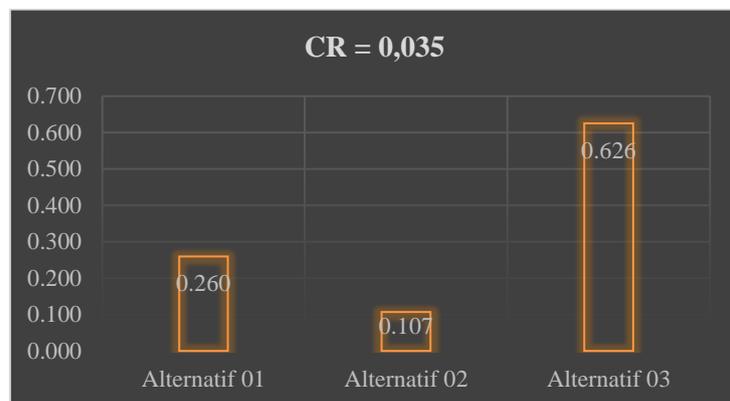


Figure 14. Alternative Locations Weight on Legality Sub-criteria

The location who has the highest value for the best legality sub-criteria is location 03 with a value of 0,626, this shows that location 03 is the alternative with the best legality. Location 01 has a value of 0,260, second. And for the third order of this sub-criterion is location 02 with a value of 0,107.

#### 4.15. Location Priority Weight

The following will be analyzed the final weight of alternative locations priority on each sub-criteria and criterion as in Table 3 below.

**Table 1. Weighting Final Result Priority Location**

Alternative	Weigh	Rank
Location 01	0,20103	3
Location 02	0,25719	2
Location 03	0,53840	1

After analyzing the priority criteria, sub-criteria, and location weights, it can be seen intable 3 that location 03 has the best with a value of 0,53840 compared. Followed by location 02 has a performance value of 0,25719, and alternative locations who has the lowest location 01 performance value has a performance value of 0,20103. This criterion can be taken into consideration in determining location in environmental lab companies.

### 5. Conclusions and Recommendations

#### 5.1 Conclusions

This study aims to make modeling in tire supplier selection based on performance evaluation with the AHP method. Based on these objectives, the conclusion that can be drawn is that there are 3 priority criteria and 9 priority sub-criteria for determining location. The AHP method gives a different order of priority:

1. From the results of calculated in Excel, the location criteria are the most important criteria, followed by the cost and facilities.
2. From the results of calculated in Excel, the environment sub-criteria are the most important sub-criteria, followed by the access and closeness to COG.
3. Location 03 was selected as the biggest weight alternative location, followed by second location 02, and alternative with the lowest weight was location 01.

#### 5.2 Recommendations

1. More criteria and sub-criteria can be added for determining location.
2. This research can be developed with other multi criteria method.
3. An application program can be design to support determining location support systems.

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