Decision Analysis on Choosing the Right Site Location of Learning Facility Using Analytic Hierarchy Process

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Abstract: This paper will be discussing on the decision analysis using Analytic Hierarchy Process. Making a decision can be challenging especially when it involves the whole organization. The complexity of the problem, the uncertainty of the outcome of the alternative will make a decision maker having a hard time to finalize his decision. Therefore, Analytical Hierarchy Process is one of the answers to help a decision maker in decision-making. AHP has been used in many areas by simplifying the complex situation through its hierarchy and putting the weight on each criterion (level 1, level 2, and so on) in that hierarchy. The pairwise comparison between criterions; and also between criterions and the alternatives will present the prioritization. The global weight can be obtained by adding up the local weight. This AHP method is applied through the following case study. The BPPTD Bali (Balai Pendidikan dan Pelatihan Transportasi Darat / Civic Education and Training of Transportation) would like to improve their human resources by increasing the learning facilities through transportation school construction facility. The right location is very crucial before making a decision. However, there are 6 factors to be considered for location selection which are legal aspect, social, economy, cultural, technical and environment. Every location will be reviewed through these 6 aspects and analyzed using AHP method. The result of this research will be used by the decision maker to decide the location, which has the highest weight.

Keywords: Analytic hierarchy process, decision, decision analysis, location.

Introduction

Making a decision is challenging especially it involves the whole organization. Several factors need to be considered before decision is made. In this case, BPPTD Bali (Balai Pendidikan dan Pelatihan Transportasi Darat/Civic Education and Training of Transportation) concerns on the land transportation. Most people depend on the land transportation. This is shown in the national OD (origin-destination) 2001 that about 95% passenger travel and freight are using land transportation. The land transportation has to serve safety, security, time accuracy, convenience and affordability in effective and efficient manner. In order to achieve this, BPPTD Bali has to focus on the human resources development. Currently, the quantity and quality of human resources are not sufficient to solve the complexity of the land transportation problems. Hence, one of the developments they should take is to increase the learning facilities through transportation school construction facility. The preliminary study has been done and there are five alternatives to be considered which are at location A; at location B; at location C; at location D and at location E. These five alternatives will be analysed with six aspects/criterions which are legal, social, economy, culture, technical and environment. With AHP, the global weight will be measured and the location is chosen from the highest global weight.

Methods

The first step is doing a preliminary study to find the criterion to be considered in selecting a location and the alternatives of the locations. The preliminary study has been done by interviewing, observing and also from literature study. The result of the first study is used to get the criterions and alternatives.

The second step is structuring the goal, criterion and alternatives into a hierarchy. Analytic Hierarchy Process is a decision making tool by structuring the complexity using hierarchy (Saaty [1]). The structure is built by putting the goal at level 1, the criterion at the level 2 and the alternatives at the level 3. AHP is used to analyse which alternatives should be chosen.

The third step is to find the intensity of importance with pairwise comparison between criterion; and between each criterion with alternatives. The scales are obtained from the decision maker (Saaty [2]). Table 1 is shown the scale for intensity of importance by Saaty.

Table1. The scale for intensity of importance by Saaty

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgement slightly favor one activity over another
5	Essential or strong importance	Experience and judgement strongly favor one activity over another
7	Demonstrated importance	An activity is strongly favored and its dominance demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgements	When compromise is needed
Reciprocals of above non-zero numbers	If activity I has one of the above non-zero numbers assigned to it when compared with activity j, then has the reciprocal when compared with i	

Once the structure is built, the measurement on a ratio scale could be done by analyzing the pairwise comparison. The scales between each criterion are obtained from the decision maker which referring to Table 1 and put it into the matrix. The next step is to analyse the weight of each criterion from the matrix. The same step is also applied to get the weight of each alternative with regards to each criterion. The formula to calculate the weight is shown in equation (1) (Saaty [2]).

$$Aw = \lambda_{max} w \quad (1)$$

A represents the matrix of pairwise comparison, $\lambda_{max}$is the largest or principal eigenvalue of A, w is the eigenvector.

The consistency answer from the decision maker has to be considered (Saaty [2]). The formula to get the Consistency Index (CI) and the Consistency Ratio (CR) are as follow:

$$CI = (\lambda\_max - n)/(n-1) \quad (2)$$

Table 2. The random indices (RI) table

Size of matrix	Random Index
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49
11	1.51
12	1.54
13	1.56
14	1.57
15	1.58

The above equation is to find the consistency index which is using λ_{max}as the eigenvalue maximum and n as the number of objects to be compared.

$$CR = \frac{CI \text{ of } A}{RI \text{ for size } n} \quad (3)$$

The CR value which is less than 10% is considered acceptable. Hence, the sensitivity analysis is the further step in order to know how high the impact of one of the criterion to the alternatives is.

Once the weight result from pairwise comparison is measured, the global weight can be obtained. The alternative which has the highest global weight is chosen. Sensitivity analysis is performed to get more detail analysis on the impact of each criterion to the selected alternative.

Results and Discussion

Data Collection

Based on the interview with the decision maker, it is obtained that the criterion for choosing the site location are as follow: legal aspect, social, economy, cultural, technical and environment. There are 5 alternatives to be considered. The hierarchy structure is shown in Figure 1.

Each criterion is having subcriterion with the following information:

1. Legal
   a. The status and land ownership
   b. Allotment of land according RT/RW
2. Social
   a. Support from the local neighbourhood
   b. Support from the local government
   c. Potential public unrest
   d. Potential disruption by Kamtibnas
3. Economy
   a. The price and the tax implied
   b. The land acquisition cost
   c. The benefit to the local economy

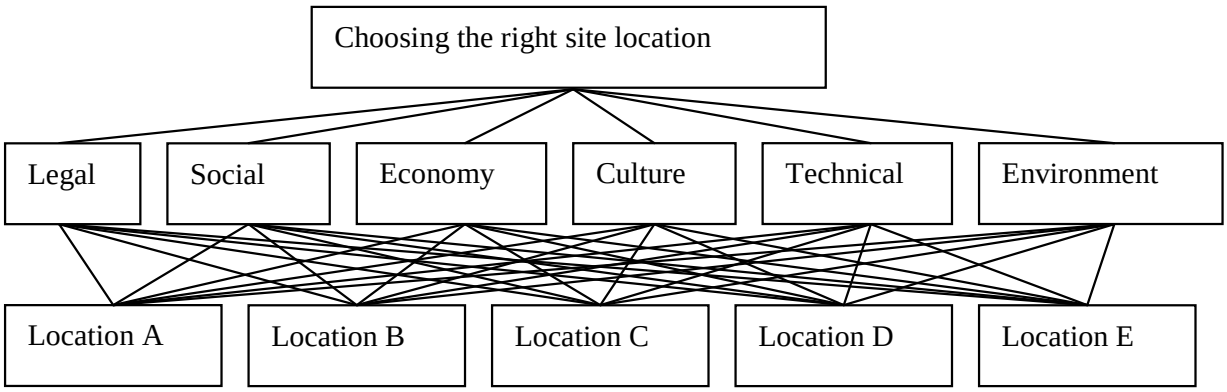

Figure 1. The hierarchy structure

Treeview

- Goal: Choosing a location
  - Legal : Legal aspect (L: .321)
    - Status : Status and Land ownership (L: .857)
    - RTRW : Allotment of land according RTRW (L: .143)
  - Social : Social aspect (L: .081)
    - Neighbourhood : Support from the local neighbourhood (L: .142)
    - Government : Support from the local government (L: .128)
    - Restless : Potential Public Unrest (L: .348)
    - Disruption : Potential disruption by Kamtibmas (L: .383)
  - Economy : Economy aspect (L: .271)
    - Price : The price and the tax implied (L: .493)
    - Acquisition : Land Acquisition cost (L: .311)
    - Benefit : Benefit to the local economy (L: .196)
  - Cultural : Cultural aspect (L: .044)
    - Conservation: Not a conservation place (L: .333)
    - Artifact : No artifact is protected (L: .333)
    - Sacred : No sacred building (L: .333)
  - Technical : Technical aspect (L: .233)
    - Accessibility : Ease of accessibility (L: .440)
    - Infrasructure : Public infrastructure availability (L: .278)
    - Topography: Topography condition (L: .105)
    - Structure: The soil structure condition (L: .105)
    - Site : Site Review (Architectural) (L: .072)
  - Environment : Environment aspect (L: .051)
    - pre-construction: Pre-construction effect to the environment (L: .400)
    - Construction: Construction effect to the environment (L: .400)
    - post-construction: Post-construction effect to the environment (L: .200)

Figure 2. The Result of the local weight on each subcriterion and criterion

4. Cultural
   a. Not a conservation place
   b. No artifact is protected
   c. No sacred building
5. Technical
   a. Ease of accessibility
   b. Public infrastructure availability
   c. Topography condition
   d. The soil structure condition
   e. Site review
6. Environment
   a. Pre-construction effect to the environment
   b. Construction effect to the environment
   c. Post-construction effect to the environment

Data Analysis

The calculation on the local weight and global weight are given in Figure 2 and Table 3.

Based on the above analysis with software expert choice, it is shown that the chosen alternative is at location A with the weight 0.312. While for the criterion, the sequence is legal (0.321), economy (0.271), technical (0.233), social (0.081), environment (0.051) and cultural (0.044). This shows that the decision maker has emphasized on the legal criterion more than the other factors. The legal criterion has 2 subcriterions which are the status and land ownership; and allotment of land according RT/RW. The result shows the status and land ownership has highest weight (0.857) which means this subcriterion is very important to the decision maker to choose a site location. Sensitivity analysis is also performed in order to know how big the impact of the criterion to the chosen alternative is. The criterions of social and cultural have very low sensitivity to the global weight, but the others are very sensitive.

Table 3. The global weight for each alternative

Location	A	0.312
Location	B	0.294
Location	C	0.145
Location	D	0.140
Location	E	0.110

For example, the weight of legal criterion is changed then the global weight might change. Hence, the decision might change as well.

Conclusion

Decision-making with qualitative data needs to be put into hierarchy. The hierarchy is structured from the goal, the criterion, the sub criterion and the alternative. Through this hierarchy, each level is being compared through pairwise comparison. With AHP, the subjectivity is translated into quantitative data and also reduced the subjectivity from the decision maker. The result on this case study has shown that legal criterion is the most important criterion to be considered by the decision maker and the location which has the highest weight is location A.

References

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