Implementation of Analytical Hierarchy Process for Tourism Decision Support System

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***Abstract*— Tourism in East Java is still not supported with a complete digital information. Currently, travel information is still scattered in various media, both in print media, or in the internet which causes confusion in determining tourist destinations. This research use a new approach in the selection of tourism. We create a new alternative in providing recommendations to the selection of tourism in East Java, according to the multi-criteria of distance, popularity, and costs. We use Analytical Hierarchy Process, a method of Decision Support System in this research. The results is this system can be used and obtain optimal results in providing travel recommendations.**

Keywords*— Decision Suport System, Analytical Hierarchy Process, Tourism.

I. INTRODUCTION

Tourism is one of the potential sectors that boost the Indonesian economy. Indonesia's geographic condition which is dominated by the shoreline became one of the favorites of tourists to visit Indonesia, such as Kuta Beach and Bunaken. Tourist attractions that are supported by a rich cultural heritage that reflects the history and ethnic diversity in Indonesia with various local languages throughout the archipelago. The combination of natural resources and the wealth of art became an important component of tourism in Indonesia.

East Java is the largest province in Java which has an area of 47.922 km² [1]. East Java has a vast mountainous and vast oceans area that has a diverse tourism and has different appeal. One of the famous icon is Bromo Mountain in Probolinggo. Besides in Probolinggo, there are also other tourist areas, such as Banyuwangi, Malang, and Pacitan.

Media maximization of information is one of effective way to increase tourism revenue. Tourism in East Java is still not supported with a complete digital information. Currently, travel information is still scattered in various media, both in print media, or in the internet which causes confusion in determining tourist destinations. Travelers should seek information on a variety of media to find out where a suitable tourist attraction to visit. In addition, the information presented is not necessarily valid. Travelers need a recommendation attractions that fit the criteria they want. Planning in the tour is important, because every tourist would want traveled effective and efficient.

Some research and technology of decision support system on tourism has many, including research by Cut Fiarni, Evasaria Sipayung, and Stephanus from the Department of Information System and Technology of Institut Harapan Bangsa which makes web-based recommendation application on the hotels selection for tourists using AHP in Bandung with the following criteria safety, comfort, and vehicle availability. This is a web-based application, so this application requires an internet connection and a browser to be used. In this application has not been furnished with digital maps appearance, so users are still confused in finding a destination location. Beside that, Verdi Septiawan from Mathematics of North Sumatra University is also researching about hotel selection decision support system for travelers using fuzzy logic clustering in Batam Island. In this research, the author makes a web-based application regarding Decision Support System in choosing hotels in Batam Island using a Fuzzy Logic with the following criteria hotel price, duration of the holiday, and the cost of the restaurant. The data clustered and will be adapted to cost budget and how long vacation. This system is built with Visual Basic 6.0 programming language and MySQL. This application is a is less free to be accessed anytime and anywhere, because it is desktop application.

This research use a new approach in the selection of tourism. We create a new alternative in providing recommendations to the selection of tourism in East Java, according to the criteria of distance, popularity, and costs. System use mobile devices that already support GPS and digital maps, so it can be used to navigate towards sights. This research use East Java tourism as case study. This research is expected to help tourists in providing recommendations tourist destination, so traveling will be more effective and efficient.

II. FUNDAMENTAL THEORIES

A. Decision Support System (DSS)

Decision support system is an interactive information system that provides information, modeling and manipulating

data. That system is used to assist decision-making in situations of semi-structured and unstructured situation where nobody knows for sure how the decision is lacking should be made.

Decision support systems are usually used to support a solution to a problem or to evaluate an opportunity. That decision support system called decision support system application. Applications using the CBIS (Computer Based Information System) which is flexible, interactive, and can be adapted, developed to support solutions for specific management problems that are not structured.

Decision support system applications using the data, providing an easy user interface, and can combine the thinking of decision-making. Decision support system is intended to support the management to do the analytical work in less structured situations and with criteria that are less clear.

Decision support system is not intended to automate decision-making, but provide interactive tools that enabling decision making to perform a variety of analyzes using available models. The purpose of the DSS are:

- To help managers in making decisions on semi-structure problems.
- Provide support for of the manager's consideration, not intended to replace the function of the manager.
- Improving the effectiveness of the taken decision more than its efficiency improvements.
- To obtain the computing speed. Computers allow the decision makers to do a lot of computing quickly at a low cost.
- Increasing productivity
- Quality support
- Competitive
- The solution of the cognitive limitations and storage processing. Maintaining the Integrity of the Specifications

B. Analytical Hierarchy Process (AHP)

Analytical Hierarchy Process (AHP) is a decision support models developed by Thomas L. Saaty. This decision support models will parse a complex multi-factor or multi-criteria problem into a hierarchy. According to Saaty, the hierarchy is defined as a representation of a complex problem in a multi-level structure where the first level is the objective, which is followed by the level of factors, criteria, sub-criteria, and so on down to the last level of the alternatives. With hierarchy, a complex problem can be decomposed into groups, then arranged into a hierarchy, so that problem would appear more structured and systematic.

AHP is often used as a method of solving problems compared with other methods for the reasons as follows:

- The hierarchical structure, as a consequence of the selected criteria, to the deepest sub-criteria.
- Consider the validity up to the limit of various criteria and alternatives inconsistent tolerance that selected by decision makers.
- Considering the durability of output analysis sensitivity of decision-making.

C. AHP Stage Methods

In the Analytical Hierarchy Process steps are as follows:

1. Defining the problem and determine the desired solution. In this stage, the authors sought to determine the issues to be resolved clearly, detail and easily to understand. the authors try to determine the solution of the existing problems, which might be suitable for such problems. The solution of the problem may amount to more than one. The solution will be developed further in the next stage.
2. Create a hierarchical structure that begins with the main objective. After compiling the main objective as the top-level, structured hierarchy level underneath, there are suitable criteria and determine alternatives. Each criterion has a different intensity.
3. Make a pairwise comparison matrix that illustrates the relative contribution or influence of each element of the destination or the criteria level above it. Matrix approach reflects double aspects of the priority which is dominating and dominated. Comparisons are made based on judgment of decision makers to judge the importance of an element than other elements. To begin the process of pairwise comparison, select a criterion from the top level of hierarchy, for example, K, and then from the level below select the elements to be compared for example E1, E2, E3, E4, E5.

TABLE I. FUNDAMENTAL SCALE FOR PAIRWISE COMPARISONS

Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favor one element over another
5	Strong importance	Experience and judgement strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another, its dominance is demostrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
Intensities of 2,4,6,and 8 can be used to express intermediate values. Intensities of 1.1, 1.2, 1.3 etc can be used for elements that are very close in importance		

TABLE II. RANDOM INDEX TABLE

N	RI
1	0.00
2	0.00
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	1.58

4. Defining pairwise comparisons in order to obtain the amount of overall value as n x [(n-1) / 2], with n is the number of compared elements. The comparison of each element will be a number from 1 to 9 which shows a comparison of the important level of an element. If an element in the matrix compared to itself, the results of the comparison is 1. 9 scale has been acceptable and can differentiate between elements intensity. The comparison results are loaded on the accordance field with the compared element. Pairwise comparison scale introduced by Saaty and its meaning can be seen at Table I.
5. Calculating eigen value and test consistency. If it's not consistent then repeated data retrieval.
6. Repeating step 3,4, and 5 for all levels of hierarchy.
7. Calculating eigen vectors of each pairwise comparison matrix which is the weight of each element for determining elements priority at the lowest level of the hierarchy until it reaches the objective. Calculations by adding up the value of each column of the matrix, dividing each column with a total value of related columns, to obtain a normalization matrix, and summing the values of each line and dividing by the number of elements to get an average.
8. Check the consistency of the hierarchy. Calculating the ratio of consistency with regard consistency index. Consistency is expected to be close to perfect in order to create a near valid decision. Although difficult to achieve a perfect score, consistency ratio expected to be less than or equal to 10%.

Formula for determining Consistency Index (CI):

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

Description:
CI = Index consistency (Consistency Index)
λmax = Biggest eigen values of n-matrix

λmax obtained by summing the results of multiplying the number of columns by eigen main vector.

If CI < 0.1 means that the matrix is consistent.

Saaty set inconsistency limit using Consistency Ratio (CR), by dividing the index of consistency with generating random values (RI). RI value depends on the ordo of a matrix.

CR Formula:

$$CI = \frac{CI}{RI} \quad (2)$$

Description:
CR = Consistency Ratio
CI = Index Consistency
RI = Random Index

III. IMPLEMENTATION

Generally, this research consist of mobile devices, web services, databases, and the adoption of AHP. Implementation stage consists of several parts, they are selection the type of criteria used and implementing AHP method.

A. Selection the type of criteria used

The criteria used in this application is the distance from the center of the city, popularity (the number of visitors per year), and admission price. The reason for choosing these criteria because the criteria are criteria that are often considered by tourists because it is quantitative, so it is easy to compare. These criteria are also directly related to the information on a tourist attraction and all of the attractions have these criteria. Collecting data for the three criteria are also easily obtained.

According to the research of Nurul Huda (2015) about the factors that affect the demand for tourism, economic factors affect a person's interest in the tour. Economic factors that are researched including admission price and distance between tourism and city. The statistics show that admission price affects the interest to travel and affects the interest to shop other competitor thing at a tourism. More expensive the ticket, traveler's purchasing power will also be lower, which decrease the interest of tourists to visit a tourism. Conversely, cheaper price ticket, will increase the interest of tourists to visit a tourism.

Equal to the distance of the tourist sites. Based on the regression results showed that the variables within a significant negative effect. The farther the distance to a tourism, the frequency of visits will decrease. This is because time and travel costs will increase. Conversely, the closer the distance, the less the cost and travel time. Beside that, the distance between the city and tourism are also affecting the interest in tour because the distance from the city will be affecting the availability of public facilities and public transport accessibility.

B. Implementing Analytical Hierarchy Process

Analytical Hierarchy Process (AHP) is a decision-making method that will yield a rational decision. Rational decision is defined as the best decision from various objectives that decision makers want to be achieved. The key to achieving a rational decision are alternatives and criteria that led to the objective, and also based on existing sources. In decision-making, carried out several stages, they are:

1. Intelligent Stage.
2. Modelling Stage.
3. Choice Stage.

1) Intelligent Stage

Intelligent stage is collecting and arranging selection criteria. In this case, there are several steps that must be considered in selecting tourism, they are:

1. Specify some alternative tourism election.

   There are 3 alternatives of tourism in this case, they are
   a. Kalongan Waterfall = Waterfall A
   b. Selogiri Waterfall = Waterfall B
   c. Wonorejo Waterfall = Waterfall C

2. Determine some criteria
   Criteria used for comparison are
   a. Criteria 1 : K1 = Visitors per years
   b. Criteria 2 : K2 = Distance from Town
   c. Criteria 3 : K3 = Entry fee

3. Determine the weight of each criterion.
   Data were obtained from book of Tourism Directory and book of Tourism in Number from East Java Tourism and Culture Department.

   a. Kalongan Waterfall
   - Visitors per years = 3000
   - Distance from Town = 17 Kms
   - Entry fee = Rp 5000,-

   b. Selogiri Waterfall
   - Visitors per years = 3200
   - Distance from Town = 20 Kms
   - Entry fee = Rp 10000,-

   c. Wonorejo Waterfall
   - Visitors per years = 3500
   - Distance from Town = 22 Kms
   - Entry fee = Rp 6500,-

2) Modeling Stage

Modelling stage consider a few things, they are:

1. Drawing a decision hierarchy

There are two objects that are discussed in this hierarchy, the criteria and alternatives. Here is a picture of Hierarchy decision.

- Purpose or object that will be discussed (Election tourism)
- Criterions (visitors per year, the distance from town, entrance fee)
- Alternatives (The names of tourism)

2. Determine the weight of each criteria based on user perception.

- Criteria of visitors per year is 4 times more important than entry fee.
- Criteria of visitors per year is 3 times more important than distance from town.
- Criteria of distance from town is 2 times more important than entry fee.

3. Create a pairwise comparison matrix.

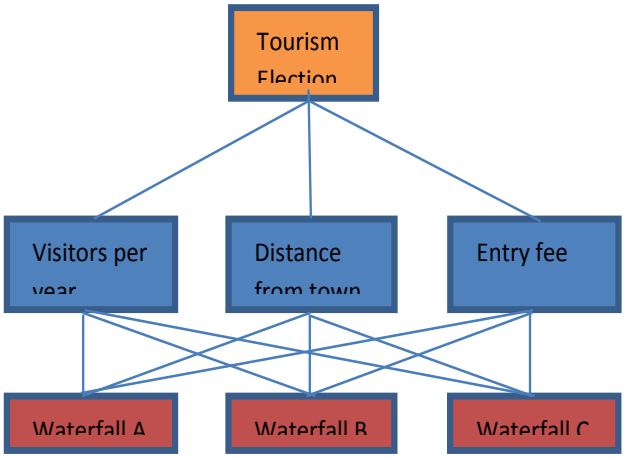

Fig. 1. Hierarchy of Tourism Recommendation

TABLE III. PAIRWISE COMPARISON MATRIX

	Visitors per year	Distance from town	Entry fee
Visitors per year	1	3	4
Distance from town	1/3	1	2
Entry fee	1/4	1/2	1

TABLE IV. TRANSFORMED MATRIX

	Visitors per year	Distance from town	Entry fee
Visitors per year	1.000	3.000	4.000
Distance from town	0.333	1.000	2.000
Entry fee	0.250	0.500	1.000
Total	1.583	4.500	7.000

TABLE V. CALCULATING NORMALIZED EIGEN VECTOR

	Visitors per year	Distance from town	Entry fee	Sum	Eigen
Visitors per year	0.632	0.667	0.571	1.870	0.623
Distance from town	0.211	0.222	0.286	0.718	0.239
Entry fee	0.158	0.111	0.143	0.412	0.137

4. Determine the ranking of criteria in a priority vector (also called normalized eigen vector).
   a. Transform matrix into a decimal, and then summing the numbers in one column.
   b. Dividing the elements of each column with total column summarization.
   c. Calculating normalized Eigen Vector by summing each line then divided by the number of criteria. The number of criteria in this case is 3.
5. Calculate the consistency ratio to validate the consistency of assessment criteria comparison.
   a. Determine the maximum Eigen value (λ_{max}).
   λ_{max} is obtained by summing the results of multiplication from decimal summarized of Pairwise Comparison matrix column with normalized eigen vector.

   λ_{max} = (1.583 x 0.623) + (4.500 x 0.239) + (7.000 x 0.137)
   = 3.025

   b. Calculating Consistency index (CI)

   $CI = \frac{(\lambda max - n)}{n-1}$
   $= \frac{(3.025 - 3)}{3-1}$
   $= \frac{(0.025)}{2}$
   = 0.013

   c. Calculating Ratio Consistency (CR)
   $CR = \frac{CI}{RI}$
   RI values for n = 3 is 0.58 (Table 2.)
   $CR = \frac{0.013}{0.58}$
   = 0.022

   Because CR < 0.100 means that preference of weighting is consistent.

3) Choice Stage

Choice stage is adjust the weighting of the criteria results with data on alternatives. Determining the ranking of alternatives by calculating eigen vector for each criteria.

TABLE VI. CALCULATING EIGEN VECTOR FOR EACH CRITERIA

	Visitors per year	Distance from town	Admission Price
Waterfall A	3000	17	5000
Waterfall B	3200	20	10000
Waterfall C	3500	22	6500
Total	9700	59	21500

TABLE VII. INVERSED VALUE

	Visitors per year	Distance from town	Admission Price
Waterfall A	3000	42	16500
Waterfall B	3200	39	11500
Waterfall C	3500	37	15000
New Total	9700	118	43000

TABLE VIII. NORMALIZED DATA

	Visitors per year	Distance from town	Entry fee
Waterfall A	0.30	0.36	0.38
Waterfall B	0.33	0.33	0.27
Waterfall C	0.36	0.31	0.35

Because Distance from Town and Admission Price are the criteria that has an inverse value, it must be changed to :

New Distance = Total Distance – Distance
New Price = Total Price – Price

So, they will be :

1. Each data must normalized to get a precision calculation by formula :

$$New\,Data = \frac{Data}{New\,Total\,Data}$$

So, they will be :

2. The recommendations produced from multiplying the value of vector criteria with alternative values. And each of the multiplication results are summed.

AHP Score =
((score of visitors per year x eigen criteria of visitors per year) +
(score of distance from town x eigen criteria of distance from town) +
(score of admission price x eigen criteria of admission price)) (4)

3. For example, AHP score of Waterfall A is:

AHP score (Waterfall A)
= ((0.30 x 0.623) + (0.36 x 0.239) + (0.38 x 0.137)
= 0.325

Score of each alternative

- Waterfall A = 0.325
- Waterfall B = 1.031
- Waterfall C = 0.346

4. From the result, the highest score is positioned on the top ranking followed by the others.
   1) Waterfall B = Selogiri Waterfall
   2) Waterfall C = Wonorejo Waterfall
   3) Waterfall A = Kalongan Waterfall

IV. Testing And Analysis

Experiments in this research is validation test in giving recommendations to a few people as sample who know the tourism in their area. The respondent determines the type of tourism in a region with the criteria in accordance with their wishes as shown in the Table X.

From the test results, obtained an analysis that the recommendations generated by the system in accordance with the expectations of users..

V. Conclusion

A. *Conclusion*

Based on the discussion and evaluation, it can be concluded as follows :

- In the Decision Support System of tourism selection is able to use Analytical Hierarchy Process method by determine the criteria and weight systematically.
- The recommendation result on this research depends on how many criteria used and type of criteria used. The selection criteria in this research adapted to the character of Indonesian travelers.

B. *Suggestion*

Suggestions for the development of this research is to develop a method by combining data mining that uses qualitative data using the rating by user.

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TABLE IX. Validation Test Results

Sample	Type of Tourism	Region	Tourism Expectation	Pairwise Comparison of Criteria	System Recommendation Rank
Sample 1	Beach	Kabupaten Banyuwangi	Plenggkung Beach	• Popularity criterion is 5 times more important than Distance criterion. • Price criterion is 3 times more important than Popularity criterion. • Price criterion is 7 times more important than Distance criterion.	1. Green Bay Beach 2. Plengkung Beach 3. Grajagan Beach
Sample 2	Historical Building	Kota Surabaya	Monument of Heroes	• Popularity criterion is 1 times more important than Distance criterion. • Popularity criterion is 3 times more important than price criterion. • Distance criterion is 4 times more important than price criterion.	1. Monument of Heroes 2. Museum House of Sampoerna 3. Museum of Healthy
Sample 3	Waterfall	Kabupaten Banyuwangi	Wonorejo Waterfall	• Distance is 4 times more important than Popularity criterion. • Popularity criterion is 2 times more important than price criterion. • Distance criterion is 7 times more important than price criterion.	1. Kalongan Waterfall 2. Wonorejo Waterfall 3. Selogiri Waterfall