BAREKENG: Journal of Mathematics and Its Application
September 2022 Volume 16 Issue 3 Page 1115–1122
P-ISSN: 1978-7227 E-ISSN: 2615-3017
https://doi.org/10.30598/barekengvol16iss3pp1115-1122

ANALYTICAL HIERARCHY PROCESS IN DETERMINING LEVEL THE FEASIBILITY OF THE AUTOMATED TELLER MACHINE LOCATION (CASE STUDY BANK SYARIAH INDONESIA JEMBER)

Agustina Pradjaningsih [1*], Dyan Mei Anggraeni[2], Kiswara Agung Santoso[3]

[1,2,3]*Department of Mathematics, Faculty of Mathematics and Natural Sciences, Jember University*
Kalimantan St., No. 37, Kampus Tegalboto, Sumbersari, Jember, 68121, Indonesia

Corresponding author e-mail: [1] agustina.fmipa@unej.ac.id*

Abstract. *Bank Syariah Indonesia (BSI) is a new Islamic bank resulting from the merger of three Islamic banks. It requires developers to maximize the feasibility of the Automated Teller Machine (ATM) location. The placement of a proper ATM location can increase the bank's profits. This research was conducted to assist BSI Jember Regency in determining the feasibility level of 10 ATM locations that are already owned based on several criteria that have been selected. This study aimed to analyze the results of the feasibility of the BSI ATM location. The method used in this study was the Analytical Hierarchy Process (AHP) method. AHP is a method used to rank the best alternative decision from several criteria that must be met or considered. In this study, four criteria and ten alternatives were used. These criteria were the distance of the ATM from the center of the crowd (X1), the distance of the ATM from the security office (X2), the number of residents (X3), and the number of non-BSI ATMs (X4), while the alternatives were 10 BSI ATM locations. This study obtained the results of the location feasibility of the establishment of 10 BSI ATMs, with the BSI KKAS UNMUH ATM, which ranked first because it had the most considerable value of 0.1674.*

Keywords: *Automated Teller Machine, Analytical Hierarchy Process, Feasibility, Rank*

Article info:
Submitted: 21st April 2022 *Accepted: 23rd August 2022*

How to cite this article:
A. Pradjaningsih, D. M. Anggraeni and K. A. Santoso, "ANALYTICAL HIERARCHY PROCESS IN DETERMINING THE FEASIBILITY LEVEL OF THE AUTOMATED TELLER MACHINE LOCATION (CASE STUDY BANK SYARIAH INDONESIA JEMBER)", *BAREKENG: J. Math. & App.*, vol. 16, iss. 3, pp. 1115-1122, September, 2022.

1. INTRODUCTION

The development of an increasingly modern era makes people prefer to save money in banks because it is more secure than at home. Banks carry out various financial transactions such as securing money, remittances, making payments, or billing [1]. There are two types of banks in the banking world: conventional and Islamic. Conventional banks are banks that, in their activities, both in collecting and distributing funds, charge rewards in the form of interest within a certain period [2]. Islamic banks carry out their business activities based on sharia principles, namely the rules of agreements based on Islamic law [3]. Increasing industry competition has forced banks to find ways to provide excellent customer service, one of which is Automated Teller Machines (ATMs). ATM is one example of the development of information technology provided by banks as a substitute for tellers. It can serve various banking transactions such as transferring money, checking balance information, making payments, and withdrawing money [4]. Determining a business location is a decision that must be made carefully because it is closely related to the success of a business [5]. Determination of proper and appropriate ATM locations can increase transactions to increase bank profits [6]. Determining the location of ATMs that meet the criteria can also help banks in global banking competition [7]. The increasingly fierce global banking competition requires banks to make decisions to determine ATM locations more quickly. The decision-making can be done using the Analytical Hierarchy Process (AHP) method because it can help make decisions quickly and easily. [8].

The AHP method is a method used to rank the best decision alternative from several criteria that must be met or considered [9]. AHP is a structured method for organizing and analyzing complex decisions [10]. AHP is a decision-making method that considers qualitative and quantitative measures [11]. The AHP method has the working principle of simplifying a complex problem into a hierarchical form. The AHP hierarchy structure has three main components: objectives, criteria, and alternatives [12]. Previous research, namely research [13], concluded that calculations using a decision support system on JAMKESMAS acceptance with the AHP method were more efficient than manual calculations, and the accuracy of the data was close to perfect. Research [8] on decision support systems using the AHP and SAW methods in determining the location of ATMs can help make decisions quickly and easily. Research [14] used the AHP method to determine the location of the new BNI ATM, which obtained seven precise and strategic locations. Research [15] designed a program for implementing the AHP method in inventory control at PT. Sumber Rezeki Bersama and produce applications that can control inventory better and faster than manual calculations. This research will help the Indonesian Sharia Bank (BSI) of Jember Regency in determining the feasibility level of 10 BSI ATM locations that are already owned because BSI is a new sharia bank resulting from the merger of three Islamic banks so that it requires developers to maximize the feasibility of ATM locations. This study aimed to analyze the results of the ranking of the feasibility of BSI ATM locations using the AHP method.

2. RESEARCH METHOD

The data used in this study were primary and secondary. Primary data collection was obtained from interviews with 5 (five) BSI survey teams and Google Maps. Secondary data collection was obtained from the website of the Central Statistics Agency. The stages of data processing with the AHP method are carried out with the following steps:

a. Defining Problems and Creating Hierarchical Structures

The problem to be solved is determining the feasibility level of 10 BSI ATM locations. Based on the hierarchical structure component, the goal to be achieved is to determine the feasibility level of 10 BSI ATM locations with four criteria and ten alternatives which are presented in Table 1 below:

Table 1. Criteria and alternatives for determining the feasibility of a BSI ATM location

	Information	Symbols
Criteria	Distance from ATM to Crowd Center	X1
	Distance from ATM to Security Office	X2
	Total population	X3
	Number of non-BSI ATMs	X4
Alternative	ATM BSI Sudirman 1	Y1
	ATM BSI Sudirman 2	Y2
	ATM BSI KKAS UNMUH	Y3

Information	Symbols
ATM BSI UNMUH	Y4
ATM BSI A. Yani	Y5
ATM BSI Trunojoyo	Y6
ATM BSI Kalisat	Y7
ATM BSI Sukowono	Y8
ATM BSI Balung	Y9
ATM BSI Ambulu	Y10

The hierarchical structure of determining the feasibility level of 10 BSI ATM locations can be seen in Figure 1 below:

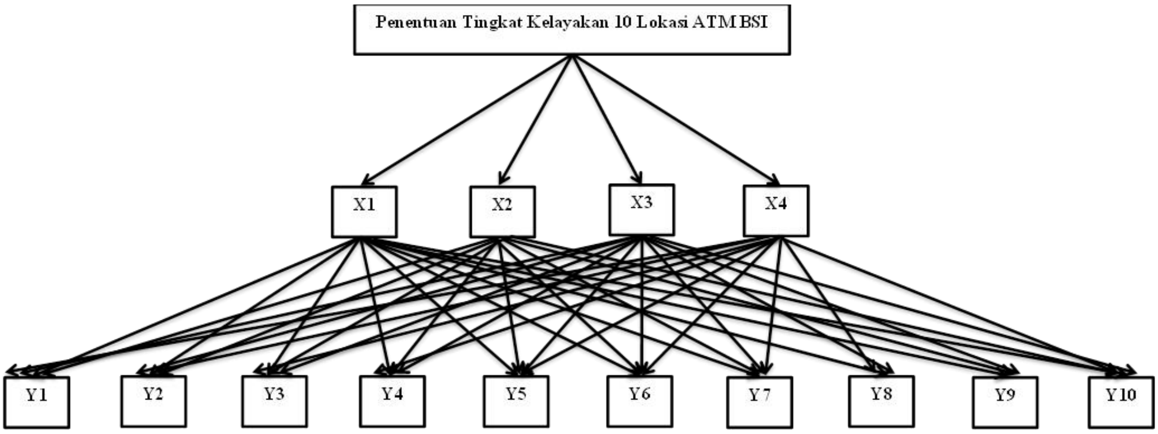

Figure 1. Hierarchical structure for determining the feasibility level of BSI ATM locations

b. Criteria Weight Calculation

The calculation of the criteria weight was carried out with the following steps:

1. Create a pairwise comparison matrix

Pairwise comparisons are carried out to compare one element's level with another. This pairwise comparison is transformed into a matrix form so the numerical calculation can be carried out. The pairwise comparison matrix assessment of each element uses a scale of 1 to 9, indicating the elements' level of importance [12]. The paired comparison rating scale can be seen in Table 2 below:

Table 2. Pairwise comparison rating scale

Interest Intensity	Definition	Explanation
1	Both elements are equally important	Two elements with equal influence in decision making
3	One element is slightly more important than the other	Experience and judgment suggest that one element is slightly more important than the others
5	One element is more important than the other	Experience and judgment suggest that one element plays a more significant role than the other elements
7	One element is more essential than the other elements	One essential and dominant element is seen in practice
9	One element is more essential than the other elements	Evidence in favor of one element is of the highest order
2, 4, 6, 8	The values between the two values of adjacent considerations. This value is given if there are two components between the two choices	
Reverse	If *i* activity gets one point compared to activity *j*, then *j* has the opposite value compared to *i*	

This pairwise comparison assessment is a group assessment, so subjective differences in values will be obtained. According to [16], the assessment subjectivity can be reduced by determining the final value using the average as in the following equation:

$$p_{ij} = \sqrt[n]{\prod_{k=1}^{n} p_{ij(k)}} \quad (1)$$

where,

p_{ij} : combined assessment of the *ij-th* element criteria/alternatives

$p_{ij(k)}$: the assessment of the *ij-th* element of the *k-th* respondent with *i,j*=1,2,3,…, m and k = $1,2,3,\dots,n$

n : number of respondents

2. Calculating weight value

The following equation was used to determine the normalization of the matrix as the first step in calculating the weight value:

$$N_{ij} = \frac{c_{ij}}{q_k} \quad (2)$$

where,

N_{ij} : the value of each element of the normalized matrix with $i, j = 1,2,\dots,n$

c_{ij} : the value of each element of the pairwise comparison matrix with $i, j = 1,2,\dots,n$

q_k : the total number of column values for each *k-th* criterion/alternative with $k = 1,2,\dots,n$.

Furthermore, from the normalization of the matrix, the weight value can be determined with the following equation:

$$w_k = \frac{\sum_{i=1}^{j} N_{ij}}{n} \quad (3)$$

where,

w_k : The weight value of *k-th* criterion/alternative with $k = 1,2,\dots,n$

N_{ij} : the value of each element of the normalized matrix with $i, j = 1,2,\dots,n$

n : many criteria/alternatives.

3. Checking hierarchy consistency

Check the consistency of the hierarchy by calculating the eigen values (λ) with the formula:

$$\lambda = \sum_{k=1}^{n} (q_k \times w_k) \quad (4)$$

where,

q_k : the total of column values for each *k-th* criterion/alternative with $k = 1,2,\dots,n$.

w_k : the weight value of *k-th* criterion/alternative with $k = 1,2,\dots,n$,

then, calculate the consistency index (**CI**) with the formula:

$$\boldsymbol{CI} = \frac{\boldsymbol{\lambda - n}}{\boldsymbol{n - 1}} \quad (5)$$

where,

CI : consistency indeks

n : the number of criteria/alternatives

λ : eigen value,

then calculate the consistency ratio (**CR**) with the formula:

$$\boldsymbol{CR} = \frac{\boldsymbol{CI}}{\boldsymbol{IR}} \quad (6)$$

where,

CR : consistency ratio

IR : Index random consistency.

The consistency ratio (**CR**), which has a value less than or equal to 0.1, indicates the calculation results are correct (consistent). If the consistency ratio (**CR**) has a value above 0.1, then the calculation results are inconsistent. Therefore, it is recommended that decision-makers do a re-comparison on the pairwise comparison matrix [12]. The list of random consistency indices can be seen in Table 3, below:

Table 3. The list of consistency random index

Matrix Size ($n \times n$)	$IR\ Value$
1×1	0
2×2	0
3×3	0,58
4×4	0,90
5×5	1,12
6×6	1,24
7×7	1,32
8×8	1,41

Matrix Size ($n \times n$)	IR $Value$
9×9	1,45
10×10	1,49
11×11	1,51
12×12	1,48
13×13	1,56
14×14	1,57
15×15	1,59

c. Calculating Alternative Weights

The alternative weights were calculated in the same steps as step b. The first step was to create an alternative paired comparison matrix against the criteria, then calculate the weight values, and check the consistency of the hierarchy.

d. Determining Ranking Results

The ranking results can be determined from each criterion's weight and the alternatives obtained. The ranking results are obtained by adding up the multiplication of each criterion weight with each alternative weight. The best alternative is the alternative that has the highest value **[12]**.

3. RESULT AND DISCUSSION

The results in this study were calculated using the AHP method. The scoring for each element of the pairwise comparison matrix was obtained from the assessment of 5 BSI survey teams based on the pairwise comparison rating scale, as shown in Table 2. The weight values for all criteria and alternatives to the criteria were obtained from the normalized pairwise comparison matrix calculation. Then, the weight values were calculated. The results can be seen in Table 4, Table 5, Table 6, Table 7, and Table 8 below.

Table 4. Weight values for all criteria

Criteria	X1	X2	X3	X4	Total	Weight
X1	0,569	0,621	0,629	0,376	2,195	0,549
X2	0,148	0,161	0,146	0,325	0,780	0,195
X3	0,140	0,171	0,154	0,205	0,670	0,167
X4	0,143	0,047	0,071	0,094	0,355	0,089

In Table 4, the most critical priority criterion is the distance between the ATM and the center of the crowd (X1) because it has the most significant weight, which is 0.549. The following criteria with essential priorities are the criteria for the distance between ATMs and security offices (X2) with a weight of 0.195, the criteria for population (X3) with a weight of 0.167, and the criteria for the number of non-BSI ATMs (X4) with a weight of 0.089.

Table 5. Alternative weight value against criteria X1

X1	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Total	Weight
Y1	0,08	0,06	0,06	0,06	0,09	0,12	0,13	0,11	0,11	0,08	0,90	0,09
Y2	0,12	0,09	0,06	0,06	0,09	0,12	0,13	0,11	0,11	0,08	0,97	0,10
Y3	0,25	0,27	0,19	0,31	0,16	0,18	0,15	0,14	0,15	0,15	1,95	0,20
Y4	0,20	0,22	0,09	0,14	0,16	0,18	0,15	0,14	0,15	0,15	1,58	0,16
Y5	0,05	0,05	0,06	0,05	0,05	0,04	0,04	0,05	0,08	0,04	0,52	0,05
Y6	0,04	0,05	0,07	0,05	0,08	0,06	0,06	0,07	0,12	0,13	0,73	0,07
Y7	0,04	0,04	0,08	0,06	0,08	0,07	0,06	0,06	0,07	0,11	0,68	0,07
Y8	0,14	0,15	0,28	0,20	0,22	0,19	0,21	0,20	0,13	0,19	1,91	0,19
Y9	0,02	0,02	0,03	0,02	0,02	0,01	0,02	0,04	0,03	0,03	0,25	0,02
Y10	0,05	0,06	0,06	0,05	0,07	0,03	0,03	0,05	0,05	0,05	0,50	0,05

In Table 5, it can be seen that the BSI KKAS UNMUH ATM (Y3) has the most crucial priority in the criteria for the distance between the ATM and the center of the crowd (X1) because it has the most significant weight, which is 0.20.

Table 6. Alternative weight value against criteria X2

X2	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Total	Weight
Y1	0,10	0,20	0,13	0,12	0,12	0,10	0,11	0,12	0,06	0,09	1,15	0,11
Y2	0,04	0,08	0,13	0,12	0,12	0,10	0,11	0,12	0,06	0,09	0,97	0,10
Y3	0,03	0,03	0,04	0,11	0,04	0,02	0,03	0,08	0,06	0,07	0,51	0,05
Y4	0,03	0,03	0,02	0,04	0,04	0,02	0,03	0,08	0,06	0,07	0,41	0,04
Y5	0,09	0,07	0,12	0,11	0,10	0,22	0,11	0,12	0,07	0,11	1,12	0,11
Y6	0,08	0,06	0,14	0,13	0,04	0,08	0,12	0,10	0,07	0,09	0,91	0,09
Y7	0,08	0,07	0,12	0,11	0,08	0,06	0,09	0,08	0,13	0,08	0,91	0,09
Y8	0,03	0,03	0,02	0,02	0,03	0,03	0,04	0,04	0,04	0,06	0,36	0,04
Y9	0,27	0,22	0,12	0,11	0,24	0,19	0,10	0,14	0,15	0,11	1,64	0,16
Y10	0,24	0,20	0,15	0,13	0,20	0,19	0,25	0,14	0,31	0,22	2,02	0,20

In Table 6, the BSI Ambulu ATM (Y10) has the most critical priority in the criteria for the distance between the ATM and the security office (X2) because it has the most prominent weight value, which is 0.20.

Table 7. Alternative weight value against criteria X3

X3	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Total	Weight
Y1	0,09	0,05	0,09	0,05	0,12	0,16	0,16	0,13	0,13	0,08	1,05	0,10
Y2	0,17	0,10	0,09	0,05	0,12	0,16	0,16	0,13	0,13	0,08	1,18	0,12
Y3	0,26	0,30	0,26	0,43	0,23	0,19	0,17	0,14	0,15	0,21	2,32	0,23
Y4	0,26	0,30	0,10	0,16	0,23	0,19	0,17	0,14	0,15	0,21	1,90	0,19
Y5	0,07	0,09	0,12	0,08	0,11	0,16	0,15	0,10	0,14	0,13	1,13	0,11
Y6	0,03	0,04	0,08	0,05	0,04	0,06	0,09	0,10	0,10	0,09	0,67	0,07
Y7	0,03	0,03	0,08	0,05	0,04	0,03	0,05	0,12	0,12	0,08	0,63	0,06
Y8	0,03	0,04	0,09	0,05	0,05	0,03	0,02	0,05	0,04	0,04	0,43	0,04
Y9	0,03	0,03	0,07	0,04	0,03	0,02	0,02	0,05	0,04	0,06	0,38	0,04
Y10	0,03	0,04	0,04	0,03	0,03	0,02	0,02	0,04	0,02	0,03	0,30	0,03

In Table 7, it can be seen that the BSI KKAS UNMUH ATM (Y3) has the most important priority to the population criteria (X3) because it has the largest weight value, which is 0.23.

Table 8. Alternative weight value against criteria X4

X4	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Total	Weight
Y1	0,08	0,03	0,08	0,07	0,14	0,07	0,06	0,11	0,11	0,13	0,87	0,09
Y2	0,27	0,10	0,08	0,07	0,14	0,07	0,06	0,11	0,11	0,13	1,13	0,11
Y3	0,10	0,14	0,11	0,22	0,07	0,16	0,18	0,08	0,10	0,12	1,28	0,13
Y4	0,10	0,14	0,04	0,09	0,07	0,16	0,18	0,08	0,10	0,12	1,08	0,11
Y5	0,09	0,12	0,26	0,21	0,16	0,12	0,18	0,16	0,15	0,14	1,57	0,16
Y6	0,08	0,11	0,05	0,04	0,10	0,08	0,06	0,08	0,11	0,08	0,78	0,08
Y7	0,09	0,12	0,04	0,03	0,06	0,09	0,07	0,08	0,13	0,08	0,80	0,08
Y8	0,13	0,17	0,26	0,21	0,18	0,18	0,16	0,18	0,10	0,11	1,67	0,17
Y9	0,03	0,04	0,05	0,04	0,05	0,03	0,02	0,08	0,04	0,04	0,41	0,04
Y10	0,02	0,03	0,04	0,03	0,05	0,04	0,03	0,06	0,05	0,04	0,40	0,04

Table 8 shows that the Sukowono BSI ATM (Y8) has the most critical priority in the criteria for the number of non-BSI ATMs (X4) because it has the largest weight value, which is 0.17. The ranking results can be calculated by adding up the multiplication of the weights of each criterion with the weight of each alternative against the criteria, which can be seen in Table 9, below.

Table 9. Ranking results

Variables	ATM Locations	Values	Ranks
Y3	ATM BSI KKAS UNMUH	0,1674	1
Y4	ATM BSI UNMUH	0,1362	2
Y8	ATM BSI Sukowono	0,1339	3
Y2	ATM BSI Sudirman 2	0,1020	4
Y1	ATM BSI Sudirman 1	0,0968	5
Y5	ATM BSI A.Yani	0,0835	6
Y6	ATM BSI Trunojoyo	0,0760	7
Y10	ATM BSI Ambulu	0,0755	8
Y7	ATM BSI Kalisat	0,0730	9
Y9	ATM BSI Balung	0,0557	10

4. CONCLUSION

Based on the results and discussions described previously, it can be concluded that the ATM BSI KKAS UNMUH ranks first with a value of 0.1612. BSI KKAS UNMUH ATM is an ATM that has a location placement with the best feasibility level according to the four criteria chosen in this study because it has the most significant value among other alternatives. BSI Balung ATM is an ATM that ranks the lowest in the feasibility of placing a BSI ATM location with a value of 0.0557. An ATM that does not rank first does not mean that the placement of the location is not feasible, but the ATM does not meet the criteria based on the assessment given by the five survey teams in this study.

REFERENCES

[1] Kasmir, *Dasar-Dasar Perbankan [Banking Basics]*, Edisi Revisi 2014. Depok: Rajawali Pers, 2018.

[2] C. Frida, *Manajemen Perbankan [Banking management]*. Yogyakarta: Garudhawaca, 2020.

[3] Ascarya, *Akad dan Produk Bank Syariah [Sharia Bank Contracts and Products]*. Jakarta: Raja Grafindo Persada, 2012.

[4] A. Ali, *Perbankan Elektronik [Electronic Banking]*. Medan: Universitas Sumatera Utara, 1992.

[5] Render dan J. Haizer, *Prinsip-Prinsip Manajemen Operasi [Operations Management Principles]*. Jakarta: Salemba Empat, 2001.

[6] Iqbal, "Keputusan untuk penentuan lokasi pembangunan ATM (Anjungan Tunai Mandiri)," ["The decision to determine the location for the construction of an ATM (Automated Teller Machine)"] *Lentera*, vol. 15, hal. 1-10, 2015.

[7] A. Putra dan M. F. Pratama, "Implementasi metode Simple Additive Weighting (SAW) untuk penentuan lokasi ATM baru," ["Implementation of the Simple Additive Weighting (SAW) method for determining the location of new ATMs"] *Jurnal Jupiter*, vol. 8, no. 1, hal. 27-38, 2016.

[8] G. S. Mahendra dan K. Y. E. Aryanto, "SPK penentuan lokasi ATM menggunakan metode AHP dan SAW," ["SPK for determining ATM locations using the AHP and SAW methods"] *Jurnal Nasional Teknologi dan Sistem Informasi*, vol. 5, no. 1, hal. 49-56, 2019.

[9] N. D. Utama, *Sistem Pendukung Keputusan: Filosofi, Teori, dan Implementasi [Decision Support Systems: Philosophy, Theory and Implementation]*. Yogyakarta: Garudhawaca, 2017.

[10] C. C. Astuti, H. Maya, K. Sari, dan N. L. Azizah, "Evaluasi e-learning menggunakan Analytical Hierarchy Process (AHP)," ["E-learning evaluation using the Analytical Hierarchy Process (AHP)"] *Barekeng Jurnal Ilmu Matematika dan Terapan*, vol. 14, no. 1, hal. 1-12, 2020.

[11] C. Fhilya, Y. A. Lesnussa, dan V. Y. I. Ilwaru, "Combination of integration analytic hierarchy process and goal programming for multi-objective optimization promotion program telecommunication services industry," *Barekeng Jurnal Ilmu Matematika dan Terapan*, vol. 15, no. 1, hal. 59-68, 2021.

[12] Diana, *Metode dan Aplikasi Sistem Pendukung Keputusan [Decision Support System Methods and Applications]*. Yogyakarta: Deepublish, 2018.

[13] A. Mardiana dan B. Majid, "Sistem pendukung keputusan pemberian kredit menggunakan metode analytical hierarchy process," ["The credit decision support system uses the analytical hierarchy process method"] *Prosiding Seminar Nasional Energi dan Teknologi*, hal. 155-159, 2018.

[14] V. Hutagaol, B. Sudarsono, dan A. Nugraha, "Penentuan lokasi ATM BNI menggunakan Analytical Hierarchy Process (AHP) dan sistem informasi geografis (studi kasus: kecamatan tembalang)," ["Determining the location of BNI ATMs uses the

Analytical Hierarchy Process (AHP) and geographic information systems (case study: Tembalang sub-district)"] *Jurnal Geodesi Undip,* vol. 4, no. 2, hal. 25-32, 2015.

[15] E. Sumarsono, “Penerapan metode AHP (Analytical Hierarchy Process) dalam pengendalian persediaan barang pada PT. sumber rezeki bersama,” [“The application of the AHP (Analytical Hierarchy Process) method in controlling inventory at PT. common source of sustenance"] *Jurnal Fakultas Teknik Universitas Potensi Utama,* hal. 34-43, 2016.

[16] T. Saaty, *Decision making for leader: the analytical hierarchy process for decisions in complex world.* Pittsburgh: University of Pittsburgh, 1993.