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FUZZY ANALYTICAL HIERARCHY PROCESS METHOD FOR HOUSING RECOMMENDATION DECISION SUPPORT SYSTEM

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ABSTRACT

Population growth in Indonesia that increases every year, encourages people to meet their basic needs, such as housing. Along with this, it encourages developers to offer various types of housing. The problem that is often faced is that consumers often feel confused in finding housing that will be chosen as a residential house that fits the criteria. The purpose of this study is to build a web-based decision support system that can provide housing recommendations that suit buyers by applying the FAHP method. This method is known for its ability to process weighting from several criteria and categories to produce several good alternative choices. There are five criteria that will be used in this study, including price, land area, building area, number of rooms, and number of floors taken from 4 developers in the city of Gresik. The results of the study show that this decision support system can help buyers in providing good housing recommendation solutions. System testing with the black box method shows that this system able to display good information. Based on the results of the questionnaire distributed to buyers, it can be concluded that the existence of this system provides benefits and positive impacts for buyers in choosing housing, with a satisfaction value of 97.2%.

Keywords: *Decision Support System; Housing; Fuzzy Analytical Hierarchy Process;*

I. INTRODUCTION

Nowadays, communication and information technology is experiencing developments. quite significant (Bianto, Rahayu dan Huda, 2018; Saputra, 2020; Aprillya dan Chasanah, 2022) .In the business world, this development is also used to provide better information system. Along with the population growth in Indonesia which increases every year, it encourages people to fulfill their basic needs, such as housing (Azhar dan Handayani, 2018; Sari dan Purwaningsih, 2021; Bintang Aryandhana, Fadli dan Ashari, 2022). According to the Department of Settlement and Spatial Planning, the need for housing is divided into two main things. First, the need for

housing is based on trends or natural population growth tendencies. Second, the need and provision of housing is based on the number of habitable houses. Along with this, it encourages developers to offer various types of housing that have their own characteristics. These characteristics will later be used as a reference for considering the house to be chosen. Because everyone wants to have a comfortable, safe and strategic home (Sari dan Purwaningsih, 2021) , often consumers feel confused in looking for housing to choose as a residential home that suits their criteria because they are faced with several choices. Decision Support System is a system that can help in making decisions in an organization or company (Jauhari dan Mufarroha, 2020; Munthe *et al.*, 2022). The advantage of a decision support system is its ability to solve complex problems both in terms of hardware and software (Shodiq, Warsito dan Gernowo, 2018). So that the decision support system is able to produce a decision quickly and has a reliable level of accuracy. There are many problems that can be solved by implementing a decision support system with the multi-criteria decision method (Limbong dan Simarmata, 2020; Nasution, 2022). The multi-criteria decision method offers systematic and precise results to overcome problems in complex decision making.

Some types of MCDM methods include the Fuzzy Analytical Hierarchy Process (Aprillya dan Chasanah, 2022), Technique for Order Preference by Similarity to the Ideal Solution (De Brito dan Evers, 2016; Bachtiar, Suyono dan Purnomo, 2021), Multi Attribute Utility Theory (Hadinata, 2018). The Fuzzy Analytical Hierarchy Process method is known for its ability to process weighting of several criteria and categories to produce several good alternative choices (Faisol, A., Muslim, M., & Suyono, 2014). This method is a development of the AHP method, where this method is considered better at describing ambiguous decisions.

The purpose of this study is to build a decision support system by applying the Fuzzy Analytical Hierarchy Process method which later this system can provide housing recommendations that are in accordance with the wishes so that it makes it easier for consumers to choose housing. This paper is structured as follows. Section 1 explains the background. Section 2 explains the research methodology. Section 3 presents the results and discussion. Section 5 presents the conclusions of the study.

II. METHOD

This study uses several criteria to produce housing recommendations, including price, land area, building area, number of rooms, and number of floors. In this study, data was taken from four housing developers in the Gresik area. The stages in system development can be started by collecting price data, land area, building area, number of rooms, and number of floors from 4 housing developers. The next process is to design a decision support system by applying the Fuzzy Analytical Hierarchy Process method. The FAHP method is used as a method in the housing recommendation process. The next step is to build a web-based system using the PHP programming language. Validation testing is done with a black box for system testing.

A. Decision Support System

Decision Support System based on interactive computer that helps taking decision in organization (Alyoubi, 2015; Fatma *et al.*, 2021). System Supporter decision using data and models to finish problem that is not structured (Aprillya dan Chasanah, 2021) so that can serve information and interpretation various alternative (Sundari *et al.*, 2019). System Supporter decision has synergized with various system management knowledge and develop currently as IS assistance is urgently needed to taking decision (Dzulkarnain, Suryani dan Aprillya, 2019). Systematics in

compile taking decision through four stages namely intelligence, design, choice, and implementation.

B. Fuzzy Analytical Hierarchy Process

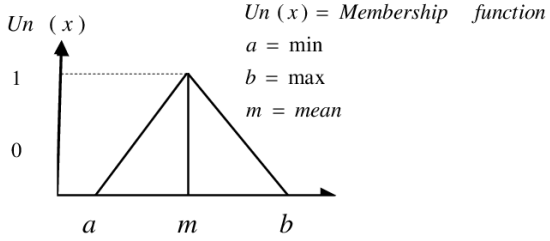
Fuzzy Analytical Hierarchy Process method is development from AHP method. Where FAHP is considered good in describe fuzzy decisions. Triangular Fuzzy Numbers (TFN) are class special from fuzzy number whose membership determined by three number real, stated as (low, middle, upper). The following are table comparison from mark scale modified linguistics become scale Fuzzy numbers are shown in Table 1.

Table 1. Intensity of Interest

Linguistic Scale	AHP	TFN
Equally Important	1	(1,1,3)
A Little More Important	3	(1,3,5)
More Important	5	(3,5,7)

The following are diagram of Triangular Fuzzy Number are shown in Diagram 1.

Diagram 1. Triangular fuzzy number



The following are the steps in the FAHP method calculation process [3], [23].

1) Defining the problem in the form of a hierarchical structure

2) Compile a comparison matrix between all criteria, then calculate the consistency ratio value of the comparison matrix with the condition that CR ≤ 0.1

3) Convert the weighting results into the TFN scale as in Table 1 above.

4) Determine the fuzzy synthetic extent value $\boldsymbol{S_i}$ with equations 1 to 3 as follows:

$$S_i = \sum_{j=1}^{m} M_{g_i}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1} (1)$$

$$\sum_{j=i}^{m} \mathrm{M}_{\mathrm{gi}}^{\mathrm{j}} = \left(\sum_{\mathrm{j}=1}^{\mathrm{m}} \mathrm{l_j}, \sum_{\mathrm{j}=1}^{\mathrm{m}} \mathrm{m_j}, \sum_{\mathrm{j}=1}^{\mathrm{m}} \mathrm{u_j}\right) \quad (2)$$

Information:
M = TFN number
m = number of criteria
j = column
i = row
g = parameters (low, medium, upper)

Whereas:

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i-1}^{n} u_i}, \frac{1}{\sum_{i-1}^{n} m_i}, \frac{1}{\sum_{i-1}^{n} l_i}\right) (3)$$

5) Determine the vector value (V) and the defuzzification ordinate value (d'). If the level of possibility between fuzzy numbers. Comparison $\boldsymbol{M_1} = (\boldsymbol{l_1}, \boldsymbol{m_1}, \boldsymbol{u_1})$ and $\boldsymbol{M_2} = \boldsymbol{l_2}, \boldsymbol{m_2}, \boldsymbol{u_2}$ and possibility $\boldsymbol{M_2} \geq \boldsymbol{M_1}$. Comparison of the level of possibility of convex fuzzy numbers can use the following equation

$$V = (M_2 \geq M_1) = \begin{cases} 1, & if\ m_2 \geq m_1 \\ 0, & if\ l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & for\ other\ condition \end{cases} (4)$$

6) So that we get a vector weight like the following five equations

$$W = \left(d(A_1), d(A_2), \ldots d(A_n)\right)^T \quad (6)$$

7) Next, normalize the fuzzy weight vector (W) values with equation 7 as follows.

$$d(A_n) = \frac{d'^{(A_n)}}{\sum_{i=1}^{n} d'^{(A_n)}} \quad (7)$$

C. Testing System

In the research, system testing was carried out using the black box method. Testing using this method is used to check the functionality of the application without seeing how it works. After the system functionality testing procedure is carried out, the next step is to test the application of the information system to the user. This is done by distributing questionnaires to 10 respondents which will be calculated using the following formula (Saputra, 2020)

$$Satisfaction\ \% = \frac{\sum Score}{S\ maximal}\ x\ 100\% \quad (8)$$

III. RESULTS AND DISCUSSION

The decision support system is built web-based. In Figure 1 is the login page by entering the correct username and password, this menu can only be used by the admin in managing master data related to housing.

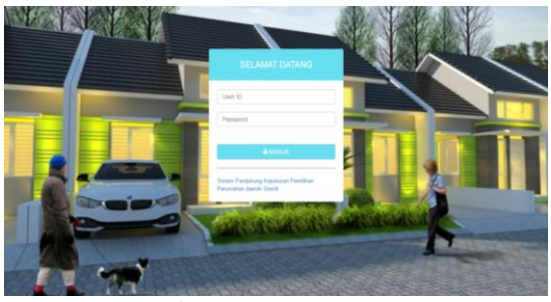


Figure 1. Login page

Figure 2 shows the housing data page that can be accessed by the admin and contains information about housing developers whose several housing types will be used as recommendations in the system.

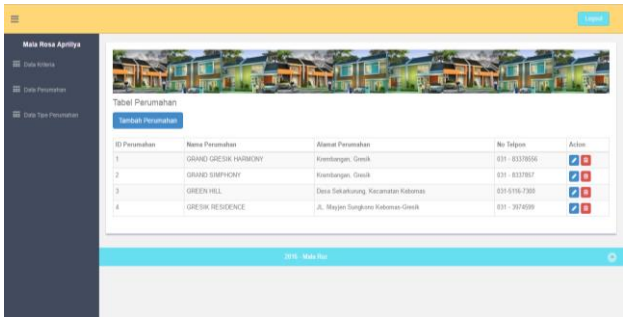


Figure 2. Developer data page

In Figure 3 is the criteria data page that can be accessed by the admin and contains the criteria used for comparative calculations in recommending housing. In this criteria data menu, the admin can edit criteria or delete criteria.

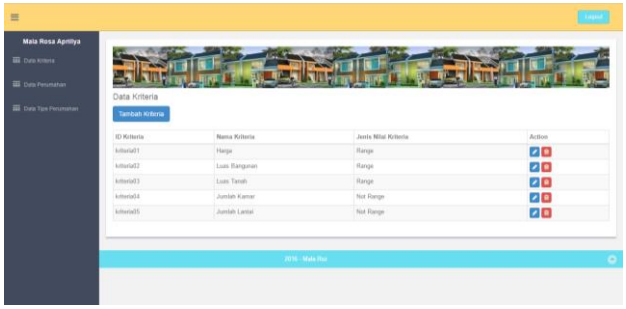


Figure 3. Criteria data page

Figure 4 shows the housing list menu page that can be accessed by customers. This page contains several types of housing from four housing developers, when clicking on the view details button, customers can see the details of the housing types offered along with their specifications.

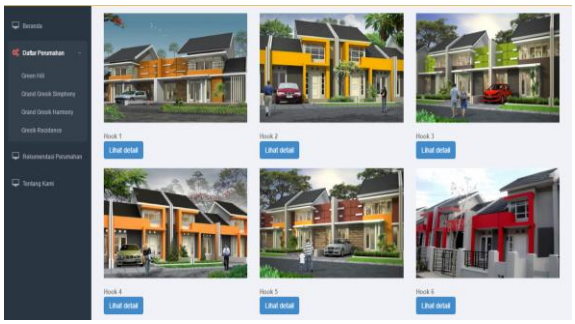


Figure 4. Figure example

In Figure 5 is a display of housing filters that customers want to search for. This filter is based on common criteria that are considered

when searching for housing, including price, land area, building area, number of rooms, and number of floors.

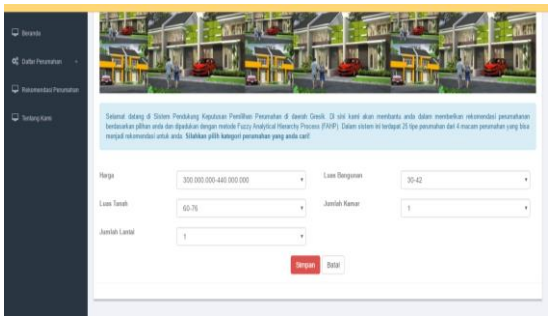


Figure 5. Figure example

Next, if you click on the save button on the previous filter menu, the customer will enter the page to input the comparison weight for each criterion shown in Figure 6 below.

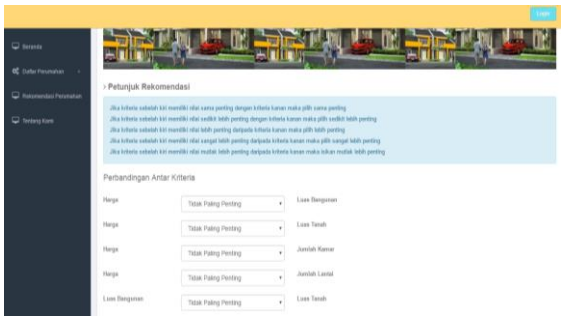
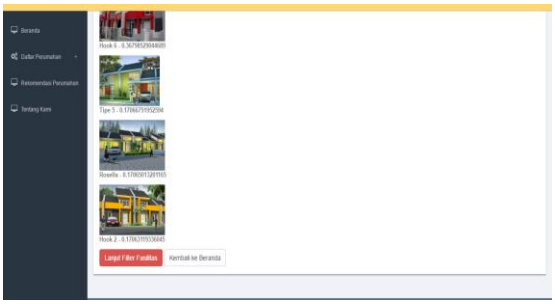


Figure 6. Figure example

After that, the housing results recommended by the system will come out based on FAHP calculations. In Figure 7 below is a recommendation results page consisting of 5 housing type recommendations where these results have been sorted from the weight of the housing type that has the highest results.



Picture 7. Figure example

Results of the Fuzzy Analytical Hierarchy Process Method. Compile a comparison matrix between all criteria, with the criteria of price (HR), building area (LB), land area (LT), number of rooms (JK) and number of floors (JL) as in Table 2 below.

Table 2. Comparison Matrix

Criteria	HR	LB	LT	JK	JL
HR	1.00	9.00	7.00	5.00	3.000
LB	0.11	1.00	5.00	3.00	3.000
LT	0.14	0.20	1.00	3.00	3.000
JK	0.20	0.30	0.30	1.00	3.000
JL	0.30	0.30	0.30	0.30	1.000
Total	1.78	10.8	6.6	12.3	13

After that, calculate the priority weight matrix and the number of criteria matrix to get the consistency ratio value with the condition CR ≤ 0.1 as in the calculation in Table 3.

Table 3. Consistency Ratio Matrix

Criteria	Amount	Priority	Results
HR	4.83	0.61	5.45
LB	1.59	0.28	1.87
LT	0.81	0.14	0.96
JK	0.59	0.10	0.69
JL	0.45	0.07	0.53
Total	9.48		

From the calculation above, the maximum value of λ is 1.89. The CI value is -0.78. The IR value is 1.24 and the consistency ratio value is -0.63, so it is stated that this matrix is consistent. Then change the results of the pairwise comparison assessment weighting into the TFN scale as in Table 1 above. The following are the results of finding the sum of each TFN number

and the results of the inverse total sum as in equation 3 shown in Table 4 below

Table 4. Inverse of total criteria

Criteria	Low	Middle	Upper
Price	17.0	25.0	31.0
Building area	6.11	12.11	18.14
Surface area	3.25	7.34	11.53
Number of Rooms	2.54	4.86	8.33
Number of Floors	1.80	2.33	5.00
Total	30.70	51.65	74.01
Inverse	0.033	0.019	0.014

After that, determine the fuzzy synthetic extent value $S_i$as in equation 1 which will be shown in Table 5 below.

Table 5. Fuzzy synthetic extent values S_i

Criteria	Low	Middle	Upper
Price	0.23	0.48	1.01
Building area	0.08	0.23	0.59
Surface area	0.04	0.14	0.38
Number of Rooms	0.03	0.09	0.27
Number of Floors	0.02	0.05	0.16

After getting the value, $S_i$the next step is to compare the level of possibility of the fuzzy synthetic extend value with its minimum value using equation 4 so that the results of the vector weights between the main criteria are obtained as in Table 6 below.

Table 6. Consistency ratio matrix

Criteria	HR	LB	LT	JK	JL
HR		0.59	0.30	0.10	0.00
LB	1.00		0.76	0.57	0.30
LT	1.00	1.00		0.83	0.55
JK	1.00	1.00	1.00		0.72
JL	1.00	1.00	1.00	1.00	
Minimum	1.00	0.59	0.30	0.10	0.30
Minimum Total Value					2.28

Next, normalize the fuzzy weight vector (W) value with equation 7. The following are the results of the weight vector which can be seen in Table 7 as follows.

Table 7. Weight vector values

Criteria	$d(A_n)$
Price	0.43
Building area	0.25
Surface area	0.12
Number of Rooms	0.04
Number of Floors	0.13

After obtaining the vector value of each criterion, the customer is asked to input the weight in the comparison of the criteria, and the range of the category of the criteria. After that, housing recommendations will be generated based on the ranking of the largest to the smallest weights and then the customer can choose the facilities sought in the housing and the system will display recommendations based on the type of facilities that have been selected. The following are the results of housing recommendations determined from the highest to the lowest weight values, which can be seen in Table 8 below.

Table 8. Housing recommendations

Home Recommendations	Total
Hook Type 8	0.3546
GG Simphony Type 1	0.3546
Hook Type 7	0.3460
Hook Type 4	0.3020
Hook Type 5	0.3020

After the functional testing procedure of the system is carried out, then testing the application of information systems to users. This is done by spreading. The questionnaire contains five questions to 10 respondents including

1. Is the housing information contained in this system useful and reliable?
2. Is this system easy to use?
3. Does this system look attractive?
4. Are the housing recommendations in this system in accordance with what you want?
5. Is this system very helpful for you in choosing housing?

For the assessment, the range of values used is 5 for strongly agree (SS); value 4 for (S); value 3 for less agree (KS); value 2 for disagree (TS); and value 1 for strongly disagree (ST). The following are the results of respondent satisfaction based on the questionnaire satisfaction shown in Table 10 below.

Table 10. Respondents' assessment

Questions	Total Score	Presentation
Q1	49	98%
Q2	47	94%
Q3	49	98%
Q4	48	96%
Q5	50	100%
Total	243	97.2%

IV. CONCLUSION

Based on the results of the study applying the FAHP method to determine housing recommendations, it can be concluded that this decision support system can help customers in providing recommendation solutions related to housing to be purchased. System testing conducted using the black box method shows that this system is able to display information well and can also provide recommendations that are in accordance with customers. Based on the results of the questionnaire distributed to customers, it can be concluded that the existence of this system provides benefits and positive impacts for customers in choosing housing, with a satisfaction value of 97.2%.

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