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COMBINING FUZZY ANP AND FUZZY ARAS METHODS FOR DETERMINING THE BEST LAND INVESTMENT LOCATION

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ABSTRACT

Determining a location for land investment cannot solely rely on intuition, as land investment is one of the economic sectors that frequently changes. Therefore, selecting a land location requires accurate analysis. The purpose of this research is to find the best land investment location using a combination of MCDM (Multi-Criteria Decision Making) methods. The scope of this research focuses on selecting land in Malang City, with the alternatives being all sub-districts in the city. As an initial step, this research employs the Delphi Technique to identify, shortlist, and evaluate the criteria considered by experts in land investment assessment. Six land investment experts participated in this study. The MCDM method used in this research involves two approaches. The weighting of criteria is conducted using the Analytic Network Process (ANP) method, chosen for its ability to account for interrelationships between criteria and alternatives. Following this, the ranking stage utilizes the Additive Ratio Assessment (ARAS) method, which provides utility function values to determine the efficiency of alternatives. To reduce panelist subjectivity, this research uses trapezoidal fuzzy numbers, which are generally better than triangular fuzzy numbers often used in other studies. The assessment results of criteria and sub-criteria indicate that the panelist weightings achieved good hierarchical consistency. From the ANP method combined with the Delphi technique, the Road Access sub-criterion was identified as having the highest weight, followed by the Land Profitability Index sub-criterion, and subsequently by seven other sub-criteria considered in this investment problem. The final outcome of this research, which combines the ANP and ARAS methods with fuzzy usage, shows that the relative efficiency of viable alternatives is directly proportional to the relative impact of the main criteria values and weights considered in the investment. The Arjowinangun sub-district also emerged as the best alternative for land investment.

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1. INTRODUCTION

Investment is a popular activity among the Indonesian population. Investment is one of the most important variables in driving a country's economy [1]. According to [2] emphasizes that the fundamental aspects of investment that investors must understand include market knowledge, types of investment instruments, return rates, and risk levels. According to [3], the forms of investment in macroeconomics can include land investment or real estate investment, this affects economic growth and development in rural areas as well as macroeconomics in urban settings.

Although it may appear straightforward and potentially highly profitable, land investment carries significant risks. Therefore, it is essential to conduct thorough analyses to determine the best land investment options. To assist investors, a Decision Support System (DSS) is necessary. The primary objective of this DSS is to address the challenges of Multiple Criteria Decision Making (MCDM) in selecting the optimal land investment. The MCDM is a decision-making method that selects the best option based on certain criteria that are often conflicting [4].

There exists a substantial body of research on identifying optimal land investment locations through the application of MCDM methods. Relevant studies include those by [5], [6], and [7]. However, these investigations generally concentrate on predefined locations and are confined to specific areas. The distinctive advantage of this study is its comprehensive approach, which seeks to evaluate all potential alternatives within a designated region, specifically encompassing all sub-districts in the city of Malang, East Java, Indonesia.

Several methods are commonly employed to solve MCDM problems, including the Analytic Network Process (ANP) and Additive Ratio Assessment (ARAS) methods. The ANP method, introduced by Saaty, was developed to overcome the limitations of the earlier Analytic Hierarchy Process (AHP) method, particularly its inability to account for interdependencies between criteria and alternatives [8]. ANP has been widely used in investment selection. Referring to [9], which provides a comprehensive review of various applications of the ANP method, the ANP method has been widely used, as demonstrated in [10], [11], [12], and [13]. The ARAS method, introduced by [14], has also been extensively applied in decision-making problems, as demonstrated in [15], [16] and [17]. Based on [18], this method is considered highly suitable for decision-making in the context of investment.

A key challenge in addressing MCDM problems is the subjectivity of evaluators. To mitigate this subjectivity, Zadeh introduce fuzzy sets. In 1970, Bellman and Zadeh introduced fuzzy sets into the MCDM literature [19]. By utilizing fuzzy logic, complexity can be simplified and diverse opinions and subjectivity in weighting values can be accommodated [20]. Triangular fuzzy numbers are frequently used in MCDM due to their simplicity.

This study builds on previous research by modifying two MCDM methods, ANP and ARAS, and incorporating fuzzy logic due to its tolerance for imprecise data. Trapezoidal fuzzy numbers are used in this study because, as [21] suggest, they better accommodate the subjective uncertainty of evaluators. The Fuzzy ANP method is applied to determine the weights of each criterion, while the ranking function in ANP is replaced with the ARAS method. This substitution is made because the ARAS method allows for both cost and benefit criteria and can calculate utility degrees. Additionally, weighting in the ARAS method is omitted in favor of the ANP method's weighting, which ensures hierarchical consistency, an important factor given the potential for inconsistency in evaluator assessments.

2. RESEARCH METHODS

The types of data used in this study are primary and secondary data. The primary data sources for this research are direct interviews with staff from the Malang City Land Office (Kantor Pertanahan Kota Malang), the Department of Public Works, Housing, and Settlement Area Arrangement Office (DPUPRPKP / Dinas Pekerjaan Umum, Perumahan, dan Penataan Kawasan Permukiman), the Development Planning Agency (Bappeda / Badan Perencanaan Pembangunan Daerah), as well as land notaries and individuals experienced in land investment. The secondary data sources include data from the BPN, Bappeda, DPUPRPKP, the Education Office, and the Central Statistics Agency (BPS / Badan Pusat Statistik) of Malang City.

One of the strengths of this study is that it uses all the urban villages in Malang City as alternatives. The initial number of alternatives to be used is 57 sub-districts. To meet the data requirements, the following data will be sought from the aforementioned sources:

1. Factors influencing land investment decisions.
2. Major government programs that will affect land prices.
3. Strategic locations for land investment.
4. Issues that may affect land prices in Malang City.
5. Data on land sales transactions for the year 2021.
6. Data on social and public facilities in Malang City.
7. Data on disasters in Malang City.
8. Data on the planning of social facilities, public facilities, office buildings, and economic zones up to the year 2037.

The steps to be undertaken in this research are as follows:

2.1 Delphi Technique

Before weighting the criteria, the first step in this process is problem identification and hierarchy construction. Problem identification and hierarchy construction involve determining criteria and alternatives. In this research, hierarchy construction is carried out using the Delphi technique.

The Delphi technique is employed as an initial stage of the research. This technique aims to identify, shortlist, and assess the criteria considered by land experts. The Delphi technique is conducted in three phases, with a panelist consisting of six experts. The details of these six experts are presented in **Table 1**. Before interviewing the experts, we had determined 14 criteria to be used as the initial framework. These 14 criteria were derived from previous studies on land investment selection, specifically from references **[22]** and **[23]**.

Table 1. Panelist Details for Land Evaluation

No	Expert Name	Description	Experience (in years)
1	Panelist 1	Head of Land Valuation Department, Malang City Land Office	32
2	Panelist 2	Notary and Land Deed Official	14
3	Panelist 3	Investor (Owner of Residential Investment Company)	12
4	Panelist 4	Investor (Owner of Land Investment Company)	7
5	Panelist 5	Private Residential Investor	10
6	Panelist 6	Private Residential Investor	16

2.2 Weighting Using Fuzzy ANP

The ANP method is an extension of the AHP, first introduced by Prof. Thomas Lorie Saaty in the early 1970s at Wharton Business School. ANP was developed to address the limitations of AHP in handling interdependencies among criteria or alternatives in MCDM. With the introduction of interrelated networks, ANP is more effective in situations where the relationships between elements are not entirely hierarchical **[8]**.

ANP employs a supermatrix approach, serving as an analytical tool for modeling system complexity, measuring on a ratio scale, and performing synthesis. This approach provides a more comprehensive framework for evaluating priorities. Referring to **[9]**, more than 400 research have utilized the ANP method, with some focusing on investment.

The Fuzzy ANP algorithm proposed by **[24]** can be explained as follows:

1. Forming the Hierarchical Structure of the ANP Model
2. Construct the pairwise comparison matrix among all elements as follows:

$$A = \begin{pmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{pmatrix} \tag{1}$$

where, n : number of criteria and $\tilde{a}_{ij}$: comparison value representing the performance of criterion i compared to criterion j.

3. Converting Linguistic Variables to Fuzzy Numbers Using the Scale in Table 2.

Table 2. Linguistic Comparison Scale

Numerical Scale	Linguistic Scale	Fuzzy Trapezoidal Interval Scale (n_1, n_2, n_3, n_4)
1	Equal	(1, 1, 1, 1)
2	Equal to moderate	(1, 1, 3, 4)
3	Moderate	(1, 2, 4, 5)
4	Moderate to strong	(2, 3, 5, 6)
5	Strong dominance	(3, 4, 6, 7)
6	Strong to very strong dominance	(4, 5, 7, 8)
7	Very strong dominance	(5, 6, 8, 9)
8	Strong to absolute	(6, 7, 9, 9)
9	Absolute dominance	(7, 8, 9, 9)

4. Defuzzification of Fuzzy Numbers to Check Hierarchical Consistency.

The defuzzification process uses a modification of the Best Nonfuzzy Performance (BNP) in [25]. The defuzzification of trapezoidal fuzzy numbers is computed using the equation:

$$\frac{(n_4 - n_1) + (n_3 - n_1) + (n_2 - n_1)}{4} + n_1 \tag{2}$$

5. Calculating Fuzzy Weights:

To calculate fuzzy weights, first compute the geometric mean of each row. The geometric mean of each row is calculated using the following equation:

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \cdots \otimes \tilde{a}_{in})^{\frac{1}{n}}, \qquad \forall\, i \tag{3}$$

where:

$$\tilde{a}_{ij}^{\frac{1}{n}} = \left(\tilde{a}_{ij_1}^{\frac{1}{n}}, \tilde{a}_{ij_2}^{\frac{1}{n}}, \tilde{a}_{ij_3}^{\frac{1}{n}}, \tilde{a}_{ij_4}^{\frac{1}{n}}\right), \forall i \forall j \tag{4}$$

After calculating the geometric means, the fuzzy weight for criterion j is then computed using:

$$w_i = \frac{r_i}{\sum_{j=1}^{n} r_j} \quad , \forall\, i \tag{5}$$

Where r_i representing the defuzzification result of BNP from $\tilde{r}_i$

2.3 Checking Hierarchy Consistency

Hierarchy consistency is calculated after defuzzification from the ANP method using BNP. The main objective to checking Hierarchy Consistency is to ensure that decisions made based on the hierarchy or criteria comparisons have adequate consistency. Consistency in this context refers to the extent to which evaluations or comparisons of criteria within a hierarchy do not conflict with each other. Here are the steps to calculate the consistency ratio according to [26]:

1. Summing the evaluation in each column of the comparison matrix

2. Construction of the normalized matrix
3. Calculation of the approximate scale vector $\boldsymbol{b}$
4. Determination of the approximate eigenvalue of matrix $\boldsymbol{A}$. This result is called $\boldsymbol{\lambda_{max}}$.
5. Calculate the Consistency Ratio (CR) using the following formula: $\boldsymbol{CR} = \frac{\lambda_{max}}{\boldsymbol{RI(n-1)}}$,where RI is the Random Consistency Index, referring to **Table 3**.

Table 3. Random Consistency Index Value

Pairwise Comparison Matrix Size	Random Consistency Index Value
3×3	0.58
4×4	1.90
5×5	1.12
6×6	1.24
7×7	1.32
8×8	1.41
9×9	1.45
10×10	1.49

Check the hierarchy consistency. If the consistency ratio is less than or equal to 0.1, the calculation results can be considered correct, or the hierarchical comparisons made by the evaluator are consistent. Conversely, if the consistency ratio is greater than 0.1, the evaluations need to be revised by experts. In **Table 3**, we recorded all RI values ranging from 3×3 to 10×10 because in this study, the matrix size will first be adjusted based on the results of the Delphi technique.

2.4 Ranking Using Fuzzy ARAS

Zavadskas and Turskis (2010) developed the ARAS method with the concept that complex events can be understood through simple comparisons **[14]**. This method calculates the relative efficiency of alternatives based on the values and weights of main criteria and computes the ratio of normalized and weighted criteria scores to the total criteria values. ARAS is used to rank alternatives and compare them with an ideal alternative.

However, the ARAS method cannot handle uncertainty from subjective judgments and incomplete data. To address this issue, fuzzy logic is used. The Fuzzy ARAS method is now applied in various fields such as transportation, construction, and investment. Recent studies using only the ARAS method include **[27]**, **[28]** and **[29]**. The method has also been combined with other MCDM techniques in studies such as those by **[30]**, **[31]** and **[32]**. Initially, the ARAS method utilized triangular fuzzy numbers, then Roztamzadeh, in **[21]**, introduced trapezoidal fuzzy numbers to better accommodate the uncertainty of a panelist.

In this study, the ARAS method used fuzzy numbers with trapezoidal fuzzy numbers. As described by **[21]**, the ARAS method with trapezoidal fuzzy numbers involves the following steps:

1. Form the Fuzzy Decision Matrix as follows:

$$D = \begin{pmatrix} \tilde{x}_{01} & \tilde{x}_{02} & \cdots & \tilde{x}_{0n} \\ \tilde{x}_{12} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{pmatrix} \tag{6}$$

where:

m : Number of alternatives,

n : Number of criteria,

$\tilde{x}_{kj}, k \geq 1$: Weights representing the k −th alternative for the j −th criterion,

$\tilde{x}_{0j}$: Represents the optimal value of the j −th criterion. If the optimal value of the j −th criterion is not known, then $\tilde{x}_{0j}$ is obtained as $\tilde{x}_{0j} = \max(\tilde{x}_{kj})$ for benefit criteria and $\tilde{x}_{0j} = \min(\tilde{x}_{kj})$ for cost criteria.

2. Defuzzification using the Center of Area (COA) method as described by [33] is as follows:

$$x_{kj} = \frac{1}{3}\left[a_1 + a_2 + a_3 + a_4 - \frac{a_4 a_3 - a_2 a_1}{(a_4 + a_3) - (a_2 + a_1)}\right] \tag{7}$$

3. After defuzzification, the initial values of all matrices are normalized. The matrix, where the maximum value is desired, is normalized as follows:

$$\bar{x}_{kj} = \frac{x_{kj}}{\sum_{k=0}^{m} x_{kj}} \tag{8}$$

The matrix, where the minimum value is desired, is normalized in two stages as follows:

$$x_{kj}^{*} = \frac{1}{\tilde{x}_{kj}};\ \bar{x}_{kj} = \frac{x_{ij}^{*}}{\sum_{k=0}^{m} x_{kj}^{*}} \tag{9}$$

4. Determine the weighted normalized matrix $\bar{X} = (\hat{x}_{kj})$ using the following equation:

$$\hat{x}_{kj} = \bar{x}_{kj} w_j \tag{10}$$

where:

w_j : Weight of criterion j obtained from ranking using the ANP method.

5. Determine the optimality value. The highest value of optimality value is the best, and the lowest is the worst. Therefore, the greater the optimality value, the more effective the alternative. To determine the optimality value, use the following equation:

$$S_k = \sum_{j=1}^{n} \hat{x}_{kj} \tag{11}$$

where:

S_k : The optimality value of the i −th alternative and

$\hat{x}_{kj}$: The weighted normalized value.

6. Determine the utility degree of an alternative by comparing the analyzed variant with the most ideal variant. The equation used to calculate the utility degree of an alternative is as follows:

$$K_k = \frac{S_k}{S_0} \tag{12}$$

where:

K_k : The utility degree of the k −th alternative. The higher the utility degree, the better the alternative.

Previous studies have introduced trapezoidal fuzzy numbers in the ANP method is [24] and the ARAS method is [21], but each only applied a single method. [34] combined ANP for weighting and ARAS for ranking, but without fuzzy numbers in ANP and using triangular fuzzy numbers in ARAS, which still posed a limitation in terms of subjective evaluation.

The novelty of this study lies in combining fuzzy logic with trapezoidal membership functions in the ANP method for weighting and the ARAS method for ranking. The alternatives in this study include all sub-districts in Malang City that meet the problem constraints, rather than being limited to a few land samples as in previous studies.

3. RESULTS AND DISCUSSION

In this study, the Delphi technique was applied as a method to establish relevant criteria and sub-criteria in the process of selecting land investment locations. The results from the Delphi technique were further processed to determine the weights of the criteria to be used in evaluating the alternatives, which in this case are all the sub-districts in the city of Malang. After the criteria weights were determined using the ANP method, a consistency ratio test was conducted to ensure that the assessments provided by the panelists were consistent and scientifically reliable. The final stage of this research involved the application of the ARAS method to perform the final weighting, aimed at identifying the best alternative among the sub-districts considered as potential locations for land investment.

3.1 Result of Delphi Technique

Based on the research steps previously explained, the initial results of data collection using the Delphi Technique are presented. Figure 1 shows the process of the Delphi Technique in this study. At the initial stage, the technique led to the conclusion that there were three criteria with nine sub-criteria selected by experts, as opposed to the initial four criteria and fourteen sub-criteria. The next stage is to conduct a pairwise comparison to determine how dominant one criterion is over another. The final stage of this technique is the application of Fuzzy ANP and then reviewed by the panelists to provide the final ranking.

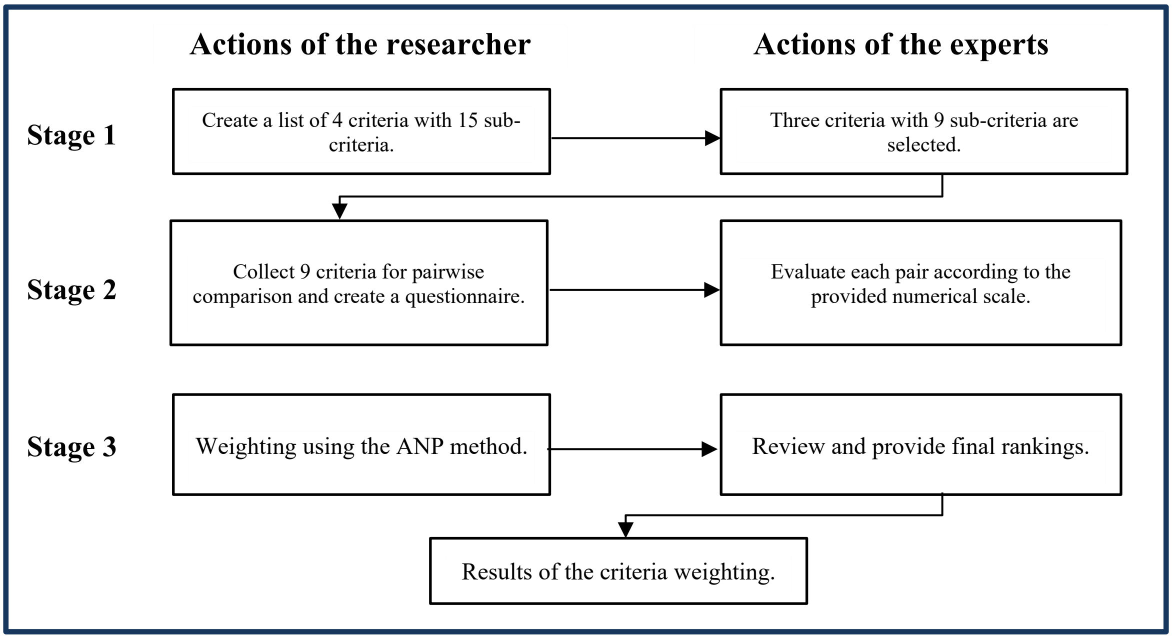

Figure 1. Delphi Process Applied In The Research

The three criteria with nine sub-criteria, after creating the Fuzzy ANP network model, are shown in Figure 2. There are finance criteria with three sub-criteria, environment criteria with four sub-criteria, and future prospects criteria with two sub-criteria. The criteria and sub-criteria in the Fuzzy ANP network model still have a relationship as seen in Figure 2. On the other hand, six sub-criteria were excluded from the land investment selection criteria. The sub-criterion of the total sale price is not included because it is already represented by the profitability index and initial investment. The sub-criterion of residential area designation is excluded because all sub-districts in Malang City have specific residential areas. The traditional village regulations are also excluded as the village regulations in Malang City are quite similar across different areas. The sub-criterion of being located within the city is not included as all alternatives are within the Malang City area. The criterion of land condition is also excluded from the land investment selection criteria because the research focuses on sub-districts within Malang City, where there are no significant differences in land condition among them.

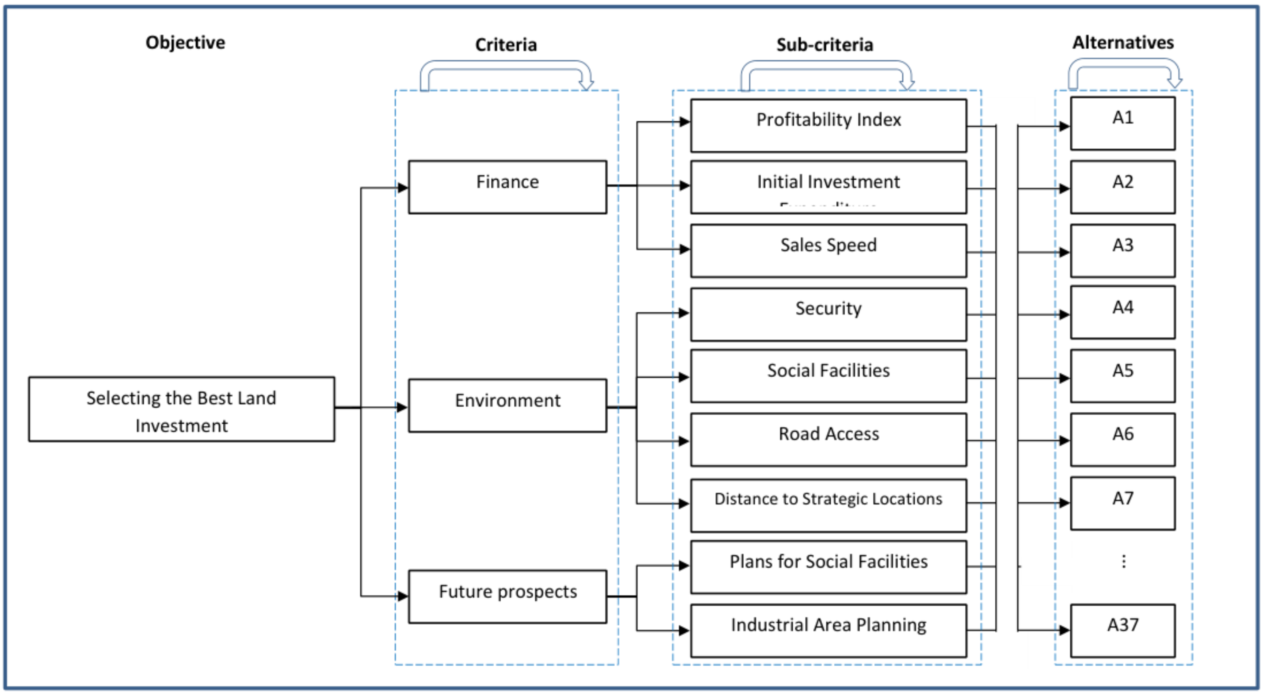

Figure 2. Fuzzy ANP Method Network Model

3.2 Result of Weighting Using Fuzzy ANP

Result of network model of the ANP Model are shown in Figure 2. After creating a network model, the next step is to conduct a pairwise comparison contained in a comparison matrix between criteria. This was done by 6 panelists, one of the pairwise comparison matrices can be seen in Table 4. The final result of the weighting using fuzzy ANP can be seen in Figure 3.

Table 4. Sample of Matrix Comparison Sub-criteria

Sub-criteria	Code	Comparison sub-criteria								
		A_1	A_2	A_3	B_1	B_2	B_3	B_4	C_1	C_2
Profitability Index	A_1	1	1	1	0.33	0.25	0.25	0.2	0.33	1
Initial Investment	A_2	1	1	1	0.33	0.25	0.2	0.2	0.25	1
Sales Speed	A_3	1	1	1	0.33	0.25	0.2	0.2	0.33	1
Security	B_1	3	3	3	1	0.2	0.2	0.14	0.2	1
Social Facilities	B_2	4	4	4	5	1	1	1	0.5	1
Road Access	B_3	4	5	5	5	1	1	0.2	1	1
Distance to Strategic Locations	B_4	5	5	5	7	1	5	1	1	1
Plans for Social Facilities	C_1	3	4	3	5	2	1	1	1	1
Industrial Area Planning	C_2	1	1	1	1	1	1	1	1	1

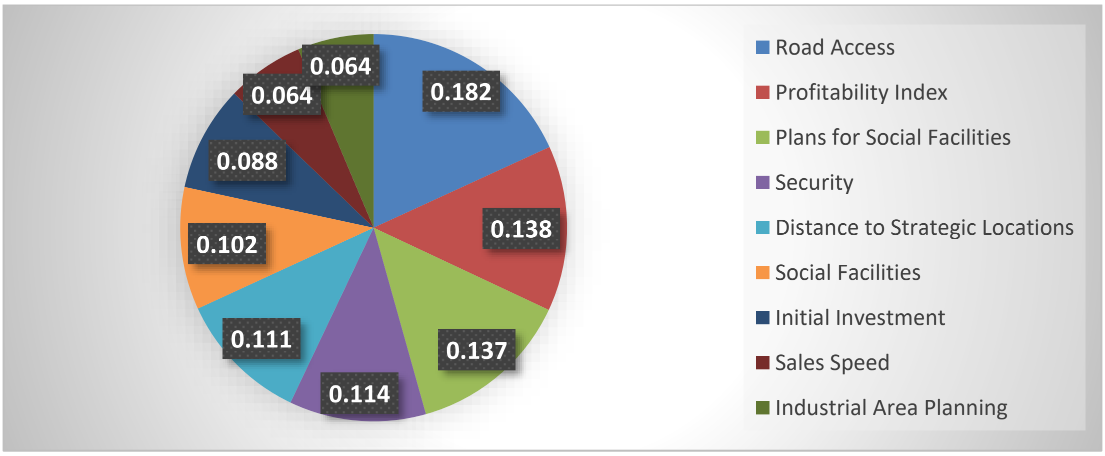

Figure 3. Weighting Results Using Fuzzy ANP Method

Figure 3 is evident that road access emerges as the most significant sub-criterion, holding a weight of 0.182, which corresponds to 18.2%. This indicates its critical importance in the evaluation process. Following closely are the profitability index and the planning of social facilities, which are also key sub-criteria. These three sub-criteria not only dominate within their respective categories but also play a pivotal role as the main sub-criteria across the various criteria provided. This highlights their overarching influence in determining the overall assessment. The five alternatives in each of the highest-ranking criteria can be seen in Table 5.

Table 5. The Alternatives with The Top 5 Rankings from The 3 Criteria With The Highest Weights.

Rank	Profitability Index		Road Access		Plans for Social Facilities	
	Sub-districts	Value	Sub-districts	Value	Sub-districts	Value
1	Arjosari	0.92	Arjowinangun	0.43	Lesanpuro	0.065
2	Balearjosari	0.92	Buring	0.43	Gadang	0.063
3	Polowijen	0.92	Kotalama	0.43	PisangCandi	0.062
4	Arjowinangun	0.80	Lesanpuro	0.43	Arjosari	0.058
5	Bunulrejo	0.80	Tlogowaru	0.43	Merjosari	0.053

3.3 Result of Checking Hierarchy Consistency

The Hierarchy Consistency Checking process is conducted after the defuzzification of the ANP method. The results of the defuzzification using the BNP method are presented in Table 6. After defuzzification, it was found that the weighting among criteria satisfies hierarchy consistency. The results can be seen in Table 7.

Table 6. Matrix Defuzzification

Sub-criteria	Code	Comparison sub-criteria								
		A_1	A_2	A_3	B_1	B_2	B_3	B_4	C_1	C_2
Profitability Index	A_1	1.00	2.08	2.65	3.25	3.37	2.62	2.50	0.60	2.41
Initial Investment	A_2	0.48	1.00	2.65	2.93	2.64	2.19	2.03	0.42	2.08
Sales Speed	A_3	0.67	0.67	1.00	3.31	3.17	2.12	2.29	0.50	2.65
Security	B_1	1.47	1.53	1.46	1.00	2.13	1.16	2.13	0.43	2.65
Social Facilities	B_2	1.77	1.85	1.82	2.24	1.00	0.56	2.38	1.66	2.78
Road Access	B_3	1.90	2.46	2.58	4.29	3.40	1.00	2.15	2.78	2.85
Distance to Strategic Locations	B_4	2.06	2.32	2.15	2.72	0.69	2.52	1.00	1.80	2.78
Plans for Social Facilities	C_1	2.58	3.98	3.05	3.84	2.39	0.61	1.80	1.00	2.85
Industrial Area Planning	C_2	1.46	1.77	0.67	0.67	0.61	0.58	0.61	0.58	1.00

Table 7. Hierarchy Consistency Table

No	Expert Name	λ_{maks}	CR
1	Overall Sub-criteria	9.0118	0.0010
2	Criteria	3.0013	0.0011
3	Financial Sub-criteria	3.0262	0.0225
4	Environmental Sub-criteria	3.7864	0.0375
5	Future Prospects Sub-criteria	2.0348	0.0600

From Table 7. it can be concluded that the pairwise comparisons in the ANP method exhibit sufficient consistency. The data shows that the values for $\boldsymbol{\lambda_{max}}$, and CR for each sub-criterion and criterion are within acceptable limits. with all CR values being less than or equal to 0.1. This indicates that the weights assigned to each criterion and sub-criterion are acceptable and can be used in the evaluation process.

3.4 Result of Ranking Using Fuzzy ARAS

Using the Fuzzy ARAS method. the final evaluation results for all 37 sub-districts in Malang City have been obtained. The analysis identifies Arjowinangun. located in the Kedungkandang district. as the top location for land investment. with a utility degree of 70.3%. This sub-district is ranked first due to its high utility score. The subsequent top-ranked sub-districts are as follows: Arjosari in the Blimbing district with a utility degree of 66.3%. Buring in the Kedungkandang district with 65.0%. Tlogowaru also in Kedungkandang with 64.8%. and Kotalama in Kedungkandang with 64.3%.

The detailed rankings of all sub-districts are provided in Table 8. which includes their respective utility degrees and ranks. The table further shows that Arjowinangun leads the list. followed by Arjosari. Buring. Tlogowaru. and Kotalama. all of which are also highly ranked in terms of investment potential. It is apparent that the five sub-districts with the highest final scores all rank within the top five in at least one of the three primary criteria shown in Table 5. This observation suggests that the value of the alternatives is directly proportional to the relative impact of the criteria's values and weights considered in the investment decision.

Table 8. Hierarchy Consistency Table

Rank	Sub-district	District	Optimal Value	Utility Degree
1	Arjowinangun	Kedungkandang	0.0362	70.3%
2	Arjosari	Blimbing	0.0341	66.3%
3	Buring	Kedungkandang	0.0335	65.0%
4	Tlogowaru	Kedungkandang	0.0334	64.8%
5	Kotalama	Kedungkandang	0.0331	64.3%
6	Polowijen	Blimbing	0.0322	62.5%
7	Lesanpuro	Kedungkandang	0.0320	62.2%
8	Jatimulyo	Lowokwaru	0.0308	59.9%
9	Dinoyo	Lowokwaru	0.0304	59.1%
10	Gadang	Sukun	0.0304	59.0%
11	Wonokoyo	Kedungkandang	0.0285	55.4%
12	Bumiayu	Kedungkandang	0.0285	55.3%
13	Mojolangu	Lowokwaru	0.0280	54.3%
14	Bunulrejo	Blimbing	0.0274	53.2%
15	Kebonsari	Sukun	0.0270	52.5%
16	Tlogomas	Lowokwaru	0.0269	52.3%
17	Cemorokandang	Kedungkandang	0.0267	51.8%
18	Purwodadi	Blimbing	0.0265	51.6%
19	Balearjosari	Blimbing	0.0260	50.5%

Rank	Sub-district	District	Optimal Value	Utility Degree
20	Merjosari	Lowokwaru	0.0259	50.4%
21	Sawojajar	Kedungkandang	0.0252	48.9%
22	Madyopuro	Kedungkandang	0.0249	48.4%
23	Purwantoro	Blimbing	0.0244	47.3%
24	Bandulan	Sukun	0.0233	45.2%
25	Pandanwangi	Blimbing	0.0230	44.7%
26	PisangCandi	Sukun	0.0226	44.0%
27	Kedungkandang	Kedungkandang	0.0221	43.0%
28	Tunggulwulung	Lowokwaru	0.0216	42.0%
29	Tasikmadu	Lowokwaru	0.0210	40.8%
30	Karangbesuki	Sukun	0.0208	40.4%
31	Tunjungsekar	Lowokwaru	0.0198	38.5%
32	Mulyorejo	Sukun	0.0196	38.0%
33	Tulusrejo	Lowokwaru	0.0188	36.5%
34	Bakalankrajan	Sukun	0.0182	35.4%
35	Bandungrejosari	Sukun	0.0167	32.4%
36	Sukun	Sukun	0.0163	31.7%
37	Bareng	Klojen	0.0130	25.2%

4. CONCLUSIONS

By utilizing a combination of the Fuzzy ANP and Fuzzy ARAS methods. the final results reveal utility function values that determine the relative efficiency of various investment alternatives. This directly reflects the relative effects of the values and weights of the primary criteria considered in land investment location evaluations. The Fuzzy ANP method provides a systematic assessment of the weights of criteria and sub-criteria. while the Fuzzy ARAS method offers a framework for measuring the performance of alternatives based on the obtained utility function values. The integration of these two methods ensures a detailed evaluation of investment alternatives. where hierarchical checks are conducted to assess the consistency of the panelists. and utility degrees are utilized to evaluate the alternatives. Therefore. the combination of Fuzzy ANP and Fuzzy ARAS can be regarded as effective for addressing investment issues. delivering accurate and relevant results in identifying the best locations for land investment. From this study, it was also found that the best sub-criterion for land investment is road access, with a weight of 18.2%. This sub-criterion may change depending on different problem constraints. This research can also be further developed by using a broader range of alternatives, not limited to a specific city as constrained in this study.

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