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Analysis of Transportation Mode Selection at Padjadjaran University Campus Jatinangor using Fuzzy Analytic Hierarchy Process (FAHP) Method

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Abstract

Transportation has become a very attached part of human daily life as a means of mobility in activities. Each transportation user has their own goals in transportation, so the mode of transportation travel takes effect in making it easier for users to reach their goals. At Padjadjaran University, Campus Jatinangor, there are several alternative modes of transportation, namely Odong-Odong, Easy Bike, conventional motorcycle taxis, and online motorcycle taxis. Each alternative mode of transportation has varying characteristics and user needs, so it is necessary to make the right decision. This study uses the Fuzzy Analytic Hierarchy Process (FAHP) method to determine priority criteria and alternative modes of transportation suitable for use on campus. The criteria used in this study include tariff, time, comfort, safety, and environmental responsibility. The results in this study obtained the order of priority criteria, is safety, comfort, time, tariff, and environmental responsibility. Moreover, the alternative priority orders are Odong-Odong, online motorcycle taxis, Easy Bike, and conventional motorcycle taxis. That can be interpreted as the safety criteria are the most considered, and Odong-Odong is the most appropriate alternative to be used at Padjadjaran University, Campus Jatinangor.

Keywords: Transportation mode selection, multi criteria decision making, fuzzy analytic hierarchy process, triangular fuzzy numbers.

1. Introduction

Almost all human activities involve transportation to connect parties in need. Transportation has become a human requirement from the past until now in their daily activities. Starting from industry and economy to education, and everything requires transportation. According to Taşan-Kok (2017), transportation can be defined as an effort to move an object, either humans or goods, from one place to another for a specific purpose. To move it, a tool that can support it is needed, namely the mode of transportation.

Each mode of transportation has different characteristics depending on the needs, services, and geographical conditions (Departemen Hubungan, 2005). Therefore, it is necessary to consider the mode of transportation that will be used to be optimal in achieving the goal. Transportation modes can generally be divided into three major groups: land, sea, and air. In Indonesia, as a developing country, transportation modes have a variety of choices, so choosing a mode of transportation is more complicated. This diversity in the current conditions, with many choices ranging from private, public, and conventional to online modes of transportation.

Expert selection of modes of transportation that can be used makes the selection of transportation modes a problem for users, especially for the civitas academica of Padjadjaran University (Unpad) Jatinangor. The role of transportation modes in Unpad Jatinangor has become crucial because of its vast geographical conditions and uphill and downhill roads dominating it. Before becoming a campus, Unpad Jatinangor was a tea plantation area and spread to rubber plantations (https://www.unpad.ac.id/kampus-jatinangor/: 25-10-2022)—the area which is located at Jalan Ir. Soekarno Km.21, Jatinangor, Sumedang, West Java, has been transformed into a campus with an area of 175 hectares, and there are 17 faculties in it which are spread between buildings.

Unpad Jatinangor provides an on-campus transportation mode called Odong-Odong which is a facility in the form of public transportation cars. This facility is very helpful for the civitas academica in carrying out activities on campus by accessing the places they want to go to and the use of this facility is free of charge. As technology advances, Odong-Odong can now be tracked in real time through devices connected to the internet. However, some members of the civitas academica have complained that the Odong-Odong facility is not environmentally friendly and at certain times it is difficult to get access or must be willing to scramble and jostle.

In addition to Odong-Odong, one of the other facilities is Easy Bike which is an environmentally friendly solar-powered electric bicycle initiated by the Student Energy Unpad team in 2019. Currently Easy Bike has not yet been inaugurated, because it is still in the second stage of development, namely by activating the calorie and heart rate counter features, GPS (Global Positioning System), RFID (Radio Frequency Identification) which allows users to only attach electronic transaction cards through KTM, and strengthening the IoT (Internet of Things) side (https://www.unpad.ac.id/kampus-jatinangor/: 25-10-2022). Easy Bike also has another advantage that can reduce electricity usage. If Easy Bike has been inaugurated and can be fully used as a mode of transportation at Unpad, then Easy Bike will become one of the alternative modes of transportation for the civitas academica.

Several decision-making methods, including the Fuzzy Analytic Hierarchy Process (FAHP), can be used. The FAHP is a decision-making method that determines a hierarchy or order of priority for each criterion considered (Rahayu and Gustian, 2022). This method uses fuzzy logic to develop the Analytic Hierarchy Process (AHP) method, which can overcome uncertainty and subjectivity (Cebi and Karal, 2017).

Based on the above problems, this study aims to determine the appropriate mode of transportation at Unpad Jatinangor using the Fuzzy Analytic Hierarchy Process (FAHP) method. The alternatives in selecting transportation modes in this study are Odong-Odong, Easy Bike, conventional motorcycle taxi, and online motorcycle taxi.

2. Literature Review

2.1. Transportation Mode

Transportation, according to Gauthier (1970), is a means of connecting or can be said to be a bridge between parties in need. Taşan-Kok (2017) defines transportation as an effort to move, mobilize or transport people and / or goods from one place to another with a specific purpose. Transportation is close to everyday life and has various functions and benefits, ranging from industry and education to the economy. The mode of transportation is a means or tool used to move people and/or goods from one place to another (Redman, 2013).

According to Fricker (2004), the types of transportation modes are generally classified into three. Namely, the air transportation mode has aircraft and airport infrastructure modes. Water transportation modes include ships, dock infrastructure, and ports. Land transportation modes include modes such as cars, buses, and motorbikes with road infrastructure and modes such as trains with railroad infrastructure.

Fricker (2004) explained that three factors influence the selection of transportation modes, namely

1) The characteristics of the trip maker, including vehicle selection, income, and social level.
2) The characteristics of the trip, including destination, time, and distance.
3) The characteristics of the transportation system. These characteristics quantitatively include waiting time, free time required to access transportation modes, fares, and parking availability. Qualitative characteristics include comfort, trust, and safety.

Meanwhile, according to Johnston (2004), the main factors that influence the selection of transportation modes are 4 focuses, namely:

1) Road user factors. include the availability of private vehicles, ownership of a driver's license (SIM), household structure (young couples, families with children, etc.), income, other factors such as taking children to school.
2) Movement factors, including purpose of movement, time of movement, and distance traveled.
3) Facility factors, including quantitative in the form of travel time (from waiting, during movement, to arrival), transportation costs, space availability, and parking rates, while qualitative in the form of safety, comfort, reliability, and order.
4) City or zone factors, including distance from the city center and population density.

2.2. Fuzzy Set Theory

Fuzzy set theory has been developed to handle partial truth order values ranging from absolutely true to absolutely false (Emrouznejad and Ho, 2018). According to Zadeh (1975), effectively quantifying human thinking full of subjective judgments takes much work. Therefore, in 1965, Zadeh began to develop the Fuzzy Set theory, a formal theory for reading the treatment of imprecise and fuzzy estimates in uncertain environments. In fuzzy sets, there are no precise boundaries, but there is a gradual transition depending on whether to be a member of the set or not, and this transition is described by a membership function (Cebi and Karal, 2017). Fuzzy sets generalize classical sets that only take 0 and 1 (binary). In contrast, fuzzy sets take the value range [0,1] in interpreting fuzzy conditions. The fuzzy

theory uses linguistic variables that transform values into words (natural language), such as somewhat, moderately, relatively, and better.

2.3. Linguistic Variable

Linguistic variables are an important concept of Fuzzy Sets. Linguistic variables are used to express subjective human feelings and decisions (Cebi and Karal, 2017). Such subjectivity generally cannot be estimated through precise numerical values. According to Zadeh (1975), linguistic variables aim to minimize excessive complexity. The value of a linguistic variable is not a number but a word or sentence, and making decisions with words or sentences is easier than making decisions with numbers. Linguistic variables can be analyzed quantitatively and can be used to assess within a certain range rather than a single value, making it possible to obtain results that are more sensitive or close (Lin et al, 2007).

2.4. Triangular Fuzzy Numbers (TFN)

Fuzzy numbers are fuzzy subsets of real numbers that handle indeterminate numerical values (Cebi and Karal, 2017). There are several types of fuzzy numbers, such as triangular, trapezium, and bell-shaped curves, but generally, triangular fuzzy numbers are used more often. A triangular Fuzzy Number (TFN) consists of three membership functions, namely the lowest value (l), the middle value (m), and the highest value (u). TFN is defined as follows (Chang, 1996): For a fuzzy number M to $\mathbb{R}$ be TFN, i.e., membership function $\mu_M : \mathbb{R} \to [0,1]$, will be equal to

$$\mu_M = \begin{cases} \dfrac{1}{m-l}x - \dfrac{l}{m-l}, x \in [l,m] \\ \dfrac{1}{m-u}x - \dfrac{u}{m-l}, x \in [m,u] \\ \\ 0 \quad for \quad others \end{cases} \tag{1}$$

Denoted $\mu_M(x) = M = (l, m, u)$ with $l \le m \le u$ and l, m, u represent the lowest, middle, and highest values, respectively. Suppose there are TFN's namely $M_1 = (l_1.m_1, u_1)$ and $M_2 = (l_2.m_2.u_2)$, then if operated based on addition, multiplication, and inverse will be as follows:

1) $(\boldsymbol{l_1}.\boldsymbol{m_1}, \boldsymbol{u_1}) \oplus (\boldsymbol{l_2}.\boldsymbol{m_2}, \boldsymbol{u_2}) = (\boldsymbol{l_1} + \boldsymbol{l_2}, \boldsymbol{m_1} + \boldsymbol{m_2}, \boldsymbol{u_1} + \boldsymbol{u_2})$
2) $(\boldsymbol{l_1}.\boldsymbol{m_1}, \boldsymbol{u_1}) \odot (\boldsymbol{l_2}.\boldsymbol{m_2}, \boldsymbol{u_2}) = (\boldsymbol{l_1 l_2}, \boldsymbol{m_1 m_2}, \boldsymbol{u_1 u_2})$
3) $(\boldsymbol{\lambda}, \boldsymbol{\lambda}, \boldsymbol{\lambda}) \odot (\boldsymbol{l_2}.\boldsymbol{m_2}, \boldsymbol{u_2}) = (\boldsymbol{\lambda l_2}, \boldsymbol{\lambda m_2}, \boldsymbol{\lambda u_2}), \boldsymbol{\lambda > 0}, \boldsymbol{\lambda} \in \mathbb{R}$
4) $(\boldsymbol{l_1}, \boldsymbol{m_1}, \boldsymbol{u_1})^{-1} \approx \left(\frac{\boldsymbol{1}}{\boldsymbol{u_1}}, \frac{\boldsymbol{1}}{\boldsymbol{m_1}}, \frac{\boldsymbol{1}}{\boldsymbol{l_1}}\right)$

2.5. Analytic Hierarchy Process (AHP)

AHP was first introduced by Thomas L. Saaty in 1980, a theory of judgment aimed at finding a ratio scale or hierarchy by conducting pairwise comparisons between factors (Kosasih et al., 2020). There are four principles in AHP (Saaty and Vargas, 2012):

1) Decomposition, is solving a complete problem until it becomes an element that cannot be broken down again.
2) Comparative Judgment, is the process of comparing with the variable scale arrangement shown in Table 1.
3) Synthesis of Priority, which is looking for eigenvector values to get the main priority or local priority.
4) Logical Consistency, which is determining the consistent level of the assessment results.

Table 1: Linguistic Variable Scale

Linguistic Variable Scale	Definition	Description
1	Equally important	Two criteria are equal importance
3	Slightly important	Experience trongly favored one criteria over another

5	More important	Experience and judgement strongly favored one activity over another
7	Very important	Criteria is strongly favored and it is dominance is demonstrated in practice
9	Absolute more important	The evidence favoring one criteria over another is of highest possible order of affirmation
2,4,6,8	Intermediate values	Whenever a compromise is needed
Reciprocal	If element A has one value above when compared to element B, then element B has the opposite value to element A.	

Source: Saaty and Vargas (2012)

2.6. Fuzzy Analytic Hierarchy Process (FAHP)

FAHP is a combination of the AHP method with the Fuzzy concept. Knowing that AHP has a weakness with its inability to overcome fuzzy problems, the combination with the Fuzzy concept is an alternative that can be used to handle fuzzy decision-making cases. FAHP can minimize fuzziness in decision-making because the FAHP method uses range values, not precise numbers (crisp), in determining the level of comparison. This method was first introduced by Van Laarhoven and Pedrycz (1983) using a Triangular Fuzzy Number (TFN) in a pair comparison matrix (Emrouzned and Ho, 2018). Over time, this method continues to evolve, with several studies conducted to determine the level of inferred criteria and subjective perceptions.

The difference between the FAHP method and AHP is to replace the pairwise comparison matrix following the Triangular Fuzzy Number (TFN) rule. Problem solving steps using the FAHP method, that is:

1) Create main objectives, criteria, and preferred alternatives in a hierarchical structure as shown in Figure 1.

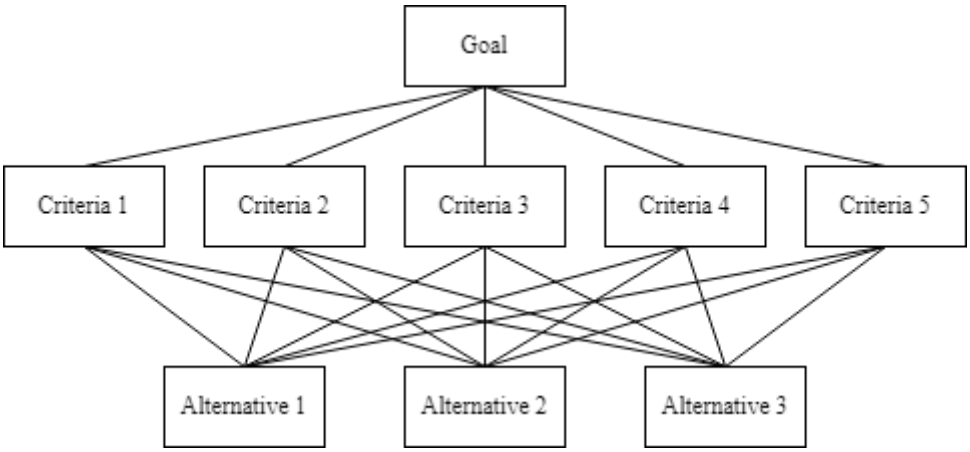

Figure 1: Hierarchical Diagram

2) Create a pairwise comparison matrix for all criteria based on the data that has been collected. For example, there are n objects and A criteria which are denoted by $(A_1, A_2, \ldots, A_n)$ which are then assessed based on the value of the level of importance between element i the denoted by A_i and elemnet j the denoted by A_j represented in the pairwise comparison matrix which can be seen in Table 2.

Table 2: Pairwise Comparison Matrix

	A_1	A_2	...	A_n
A_1	a_{11}	a_{12}	...	a_{1n}
A_2	a_{21}	a_{22}	...	a_{2n}
⋮	⋮	⋮	⋮	⋮
A_n	a_{n1}	a_{n2}	...	a_{nn}

Source: Saaty and Vargas (2012)

Comparison of the importance of the same elements, such as $a_{11}, a_{22}, \dots, a_{nn}$ will always have a value of 1. As for the ratio of the importance of the element j to i the magnitude is $\frac{1}{a_{ji}}$, this is called the inverse or reciprocal, in this case the value .$a_{21} = \frac{1}{a_{12}}$.

3) Changing the AHP linguistic scale assessment into a Triangular Fuzzy Number (TFN) variable with the TFN membership function consisting of the lowest value (l), the middle value (m), and the highest value (u) can be seen in Table 3 for the scale used.

Table 3: TFN Scale

Linguistic Variable Scale	Fuzzy Scale	Inverse
1	$(\mathbf{1},\mathbf{1},\mathbf{1})$	$(\mathbf{1},\mathbf{1},\mathbf{1})$
2	$(\mathbf{1},\mathbf{2},\mathbf{3})$	$\left(\frac{\mathbf{1}}{\mathbf{3}},\frac{\mathbf{1}}{\mathbf{2}},\mathbf{1}\right)$
3	$(\mathbf{2},\mathbf{3},\mathbf{4})$	$\left(\frac{\mathbf{1}}{\mathbf{4}},\frac{\mathbf{1}}{\mathbf{3}},\frac{\mathbf{1}}{\mathbf{2}}\right)$
4	$(\mathbf{3},\mathbf{4},\mathbf{5})$	$\left(\frac{\mathbf{1}}{\mathbf{5}},\frac{\mathbf{1}}{\mathbf{4}},\frac{\mathbf{1}}{\mathbf{3}}\right)$
5	$(\mathbf{4},\mathbf{5},\mathbf{6})$	$\left(\frac{\mathbf{1}}{\mathbf{6}},\frac{\mathbf{1}}{\mathbf{5}},\frac{\mathbf{1}}{\mathbf{4}}\right)$
6	$(\mathbf{5},\mathbf{6},\mathbf{7})$	$\left(\frac{\mathbf{1}}{\mathbf{7}},\frac{\mathbf{1}}{\mathbf{6}},\frac{\mathbf{1}}{\mathbf{5}}\right)$
7	$(\mathbf{6},\mathbf{7},\mathbf{8})$	$\left(\frac{\mathbf{1}}{\mathbf{8}},\frac{\mathbf{1}}{\mathbf{7}},\frac{\mathbf{1}}{\mathbf{6}}\right)$
8	$(\mathbf{7},\mathbf{8},\mathbf{9})$	$\left(\frac{\mathbf{1}}{\mathbf{9}},\frac{\mathbf{1}}{\mathbf{8}},\frac{\mathbf{1}}{\mathbf{7}}\right)$
9	$(\mathbf{9},\mathbf{9},\mathbf{9})$	$\left(\frac{\mathbf{1}}{\mathbf{9}},\frac{\mathbf{1}}{\mathbf{9}},\frac{\mathbf{1}}{\mathbf{9}}\right)$

Source: Helmy et al (2021)

4) Combines pairwise comparison assessments with the Geometric Mean method, with the following calculations (Helmy et al, 2021):
geometric fuzzy values (r_i) for each i criterion are as follows:

$$r_i = (a_{i1} \times a_{i2} \times \dots \times a_{in})^{\frac{1}{n}} \tag{2}$$

then determining the fuzzy weight ($\widetilde{w}_i$) for each i criterion is as follows:

$$\widetilde{w}_i = r_i \times (r_1 + r_2 + \cdots + r_n)^{-1} \tag{3}$$

With $r_k = (l_k, m_k, u_k)$ and $(r_k)^{-1} = \left(\frac{1}{u_k}, \frac{1}{m_k}, \frac{1}{l_k}\right)$, k denotes the number of $(1,2,\dots,k)$ respondents. Furthermore, the fuzzy weights $(\widetilde{w}_i) = (l_i, m_i, u_i)$ are defuzzified using the CoA (Center of Area) method as follows

$$w_i = \frac{l_i + m_i + u_i}{3} \tag{4}$$

then the fuzzy weights are normalized is as follow

$$W_i = \frac{w_i}{\sum_i^n w_i} \tag{5}$$

5) Calculate the Consistency Ratio through the following equation

$$CI = \frac{\lambda_{maks} - n}{n-1} \tag{6}$$

$$\lambda_{maks} = \frac{1}{n}\sum_{i=1}^{n} \frac{AW_i}{W_i} \tag{7}$$

$$CR = \frac{CI}{RI} \tag{8}$$

by $\boldsymbol{CI}$ showing the consistency index, $\boldsymbol{\lambda_{maks}}$ showing the largest normalized value, $\boldsymbol{n}$ showing the metric order, $\boldsymbol{CR}$ showing the consistency ratio, $\boldsymbol{RI}$ and showing the random index following Table 4. The assessment of the level of importance is said to be consistent if the value $\boldsymbol{CR \leq 0.1}$. If not, then a reassessment will be carried out as given in the Table 4.

Table 4: Random Index Value

1	0.00	6	1.24	11	1.51
2	0.00	7	1.32	12	1.48
3	0.58	8	1.41	13	1.56
4	0.90	9	1.45	14	1.57
5	1.12	10	1.49	15	1.59

Source: Helmy et al (2021)

6) Determining the global priority results by providing a ranking or sequence to the results of the multiplication of the local weight value of the criteria with the global weight of each alternative (Helmy et al, 2021).

2.7. Criteria Used

Criteria are things that are taken into consideration in determining a decision on alternative choices. In this study, the criteria used were tariff (K_1), time (K_2), comfort (K_3), safety (K_4), and environmental resposibility (K_5).

Tariff can be interpreted as burdens given to users which are generally in the form of money by adjusting to the ability of transportation service providers. In the tariff criteria, it can be measured based on indicators of compatibility between the facilities or services provided and the burden that must be paid by users. And also compatibility that burden by user revenue (Departemen Hubungan, 2005).

The time criterion referred to in this study is the length of travel time, including time in the vehicle, waiting time, and travel time to arrive at the destination. In this criterion, the indicator of regularity and accuracy of the service provider's schedule becomes a benchmark, because users can appropriately adjust the schedule (Departemen Hubungan, 2005).

The comfort criterion is defined as a condition where transportation users feel convenience, peaceful and enjoy while in the transportation facility. That situation can be measured through the availability and quality of transportation facilities towards the standard and the ratio of the number of violations to the number of trips (Departemen Hubungan, 2005).

Safety criteria are based on the reliability of service providers in minimizing accidents. These can be measured through accident rates, facilities, and systems that are able to minimize factors that compromise safety (Departemen Hubungan, 2005).

And the criteria for environmental responsibility are seen in the impact provided by services on the environment. In almost all major cities, around 80% of pollutants are contributed by transportation, especially land transportation Fricker (2004). Problems that appear along with the rapid development of transportation as a means of human mobility are noise, air pollution, pedestrian delays, traffic accidents, driver stress, and public health. Noise and air pollution are the most common and most disruptive problems. Most often air pollution is caused by the increasing number of vehicles and the use of environmentally unfriendly fuels that trigger high carbon emissions in the air. The impact of air pollution on public health including decreased reflexes, decreased visual ability, respiratory problems and headaches. respiratory problems, and headaches.

3. Materials and Methods

3.1. Materials

The object of this research is the mode of transportation that can be used at Unpad Jatinangor. The modes of transportation that referred to Odong-Odong, Solar Electric Bicycle (Easy Bike), conventional motorcycle taxis, and online motorcycle taxis. The data used is primary data obtained from 100 respondents, in this case, the civitas academica of Unpad Jatinangor, who have filled out a questionnaire. The research method used in this research is the application of the FAHP method to determine the priority hierarchy of criteria in making decisions on the most appropriate mode of transportation used at Unpad Jatinangor. Data processing and calculations in this study using Python programming.

3.2. Methods

The steps to achieve the objectives of this research are as follows:

1) Creating main objectives, criteria, and alternative choices in the form of a hierarchical structure.
2) Collecting data obtained from the results of distributing questionnaires
3) Creating a pairwise comparison matrix for each criterion
4) Transforming the pairwise comparison matrix into Triangular Fuzzy Numbers
5) Calculating the average of each pairwise comparison matrix and summarizing the pairwise comparison assessment using the Geometric Mean method in equation (2)
6) Determining the fuzzy weight value using equation (3)
7) Defuzzification with the Center of Area (CoA) method in equation (4)
8) Calculating weight normalization using equation (5)
9) Testing data consistency through the calculation of Consistency ratio (CR) using equation (8), if $CR \leq 0.1$, then it is consistent, and if $CR > 0.1$, then go back to stage 2 until the consistent CR requirement. If consistent, then repeat steps 4 through 9 for all criteria
10) Calculate global priorities and determine decisions by multiply of the local weight value of the criteria with the global weight of each alternative

These steps are depicted through a flowchart that can be seen in Figure 2.

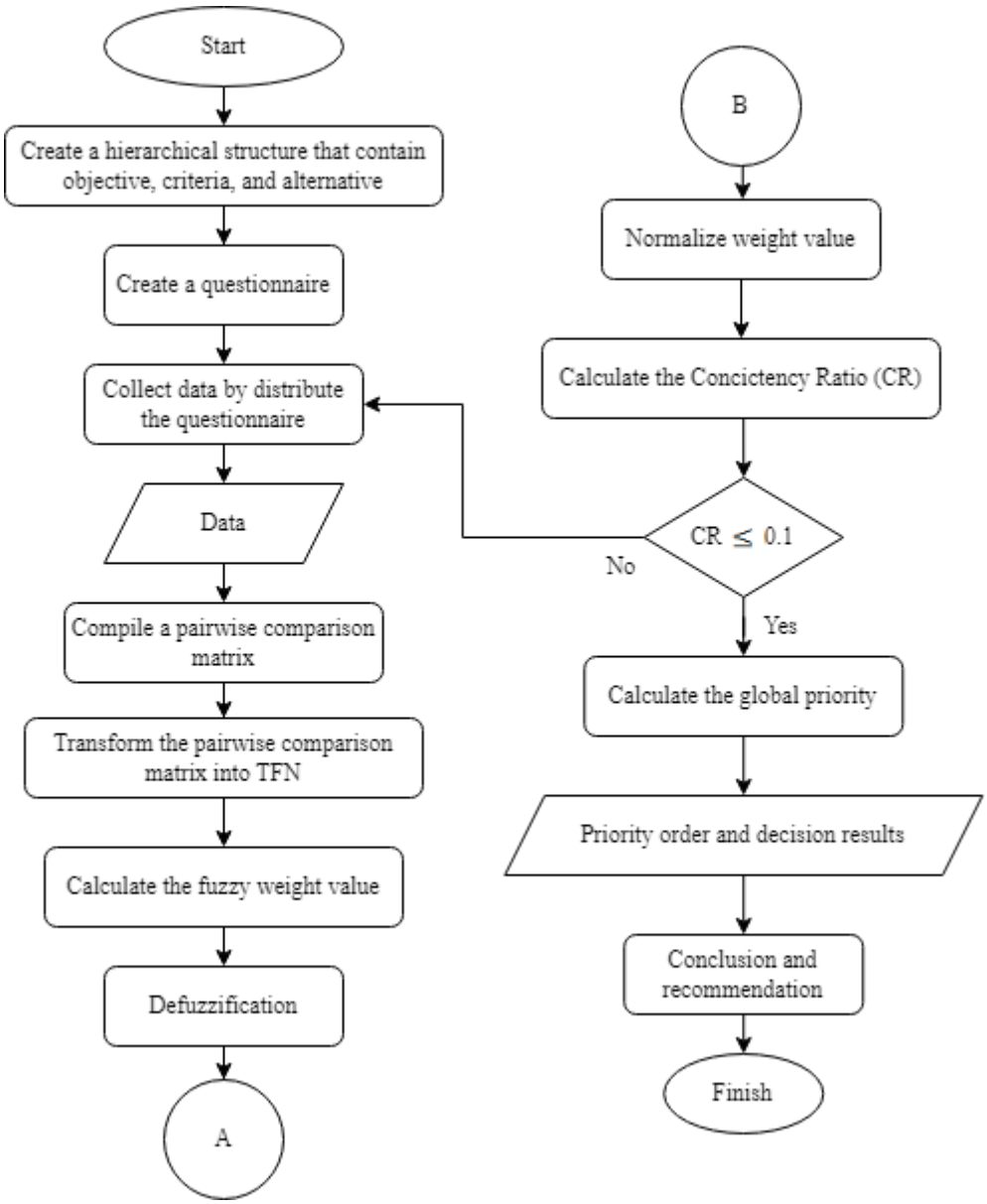

Figure 2: Flowchart Method

4. Results and Discussion

4.1. Hierarchy Structure

In this study, the best decision in choosing a mode of transportation at Unpad Jatinangor was determined using the Fuzzy Analytic Hierarchy Process (FAHP) with the alternatives used are Odong-Odong, Easy Bike, conventional motorcycle taxis, and online motorcycle taxis, as well as criteria for consideration including tariff, time, comfort, safety, and environmental responsibility.

In carrying out the FAHP method, the first step is to create a hierarchical structure. In this study, the hierarchical structure is shown in Figure 3, with three levels, at first level there are selection of transportation modes as the main goal, then at the second level there are criteria that are considered, and at the last level is the alternative used in this study.

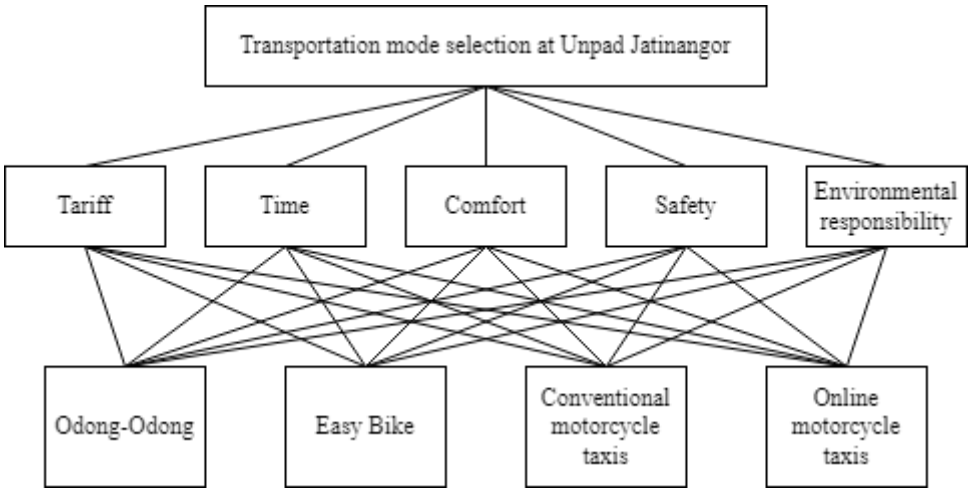

Figure 3: Hierarchical Structure

4.2. Pairwise Comparison Matrix

Based on the data obtained from 100 respondents, a pairwise comparison matrix was created following the rules in Table 1 as shown in Table 5 and then converted according to the rules in Table 3 as shown in Table 5.

Table 5: Criteria Pairwise Comparison Matrix for 1st Respondent

Criteria	K_1	K_2	K_3	K_4	K_5
K_1	1	1	8	9	$\frac{1}{6}$
K_2	1	1	7	6	$\frac{1}{7}$
K_3	$\frac{1}{8}$	$\frac{1}{7}$	1	1	$\frac{1}{8}$
K_4	$\frac{1}{9}$	$\frac{1}{6}$	1	1	$\frac{1}{7}$
K_5	6	7	8	7	1

Table 6: Criteria Pairwise Comparison Matrix of TFN for 1st Respondent

Criteria	K_1			K_2			K_3			K_4			K_5		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
K_1	1	1	1	1	1	1	$\frac{1}{9}$	$\frac{1}{8}$	$\frac{1}{7}$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$	5	6	7
K_2	1	1	1	1	1	1	$\frac{1}{9}$	$\frac{1}{7}$	$\frac{1}{8}$	$\frac{1}{7}$	$\frac{1}{6}$	$\frac{1}{5}$	6	7	8
K_3	7	8	9	6	7	8	1	1	1	1	1	1	7	8	9
K_4	9	9	9	5	6	7	1	1	1	1	1	1	6	7	8
K_5	$\frac{1}{7}$	$\frac{1}{6}$	$\frac{1}{5}$	$\frac{1}{8}$	$\frac{1}{7}$	$\frac{1}{6}$	$\frac{1}{9}$	$\frac{1}{8}$	$\frac{1}{7}$	$\frac{1}{8}$	$\frac{1}{7}$	$\frac{1}{6}$	1	1	1

4.3. Synthesise

This process aims to produce fuzzy geometric mean values (r_i) by calculating the average and combining the pairwise comparison matrix following equation (2).

Table 7: Synthesis Result for Each Criteria

Criteria	*Fuzzy Geometric Mean Value* (r_i)		
	l	m	u
K_1	0.724	0.804	0.893
K_2	0839	0.930	1.025
K_3	0.964	1,063	1.166
K_4	2,536	2,722	2,888
K_5	0.411	0.462	0.519

Furthermore, in the process of determining the value of fuzzy weights following equation (3), defuzzification with CoA following equation (4), and normalizing the weights following equation (5).

Table 8: Table of Weights for All Criteria

Criteria	$\widetilde{w}_i$			w_i	W_i
	l	m	u		
K_1	0.111	0.135	0.163	0.136	0.135
K_2	0.129	0.155	0.187	0.157	0.156
K_3	0.148	0.178	0.213	0.180	0.178
K_4	0.391	0.455	0.528	0.458	0.453
K_5	0.063	0.077	0.095	0.078	0.078

Based on Table 8 is used as a reference in determining the order of priority. So it is obtained that safety (K_4) is the first order, then comfort (K_3) is the second order, time (K_2) is the third, tariff (K_1) is the fourth, and environmental responsibility (K_5) is in the last order.

Do the same calculation for each alternative for every each criterion. So that it is obtained, that based on tariff criteria, in the first order is Odong-Odong (0.627), then in the second order is online motorcycle taxis (0.179), in the third order is Easy Bike (0.111), and in the last order is conventional motorcycle taxis (0.083). Based on time criteria, in the first order is online motorcycle taxis (0.47), in the second order is conventional motorcycle taxis (0.279), then in the third order is Odong-Odong (0.163), and in the last order is Easy Bike (0.08). Based on comfort criteria, in the first order is Odong-Odong (0.446), in the second order is online motorcycle taxis (0.281), then in the third order is Easy Bike (0.168), and in the last order is conventional motorcycle taxis (0.106). Base on safety criteria, in the first order is Odong-Odong (0.488), in the second order is online motorcycle taxis (0.217), then in the third order is Easy Bike (0.203), and in the last order is conventional motorcycle taxis (0.091). Based on environmental responsibility, in

the first order is Easy Bike (0.578), in the second order is Odong-Odong (0.261), then in the third order is online motorcycle taxis (0.095), and in the last order is conventional motorcycle taxis (0.067).

4.4. Concictency Test

The consistency test is carried out by calculating the Consistency Ratio (CR) following equations (6), (7), and (8).

Table 9: Consistency Test Result

	Consistency Ratio (CR)
All Criteria	0.01
Tariff (K_1)	0.02
Time (K_2)	0.06
Comfort (K_3)	0.02
Safety (K_4)	0.03
Environmental responsbility (K_5)	0.04

Based on Table 9, the results of the consistency test, it is declared consistent because it has a $CR \leq 0.1$. So, in the next step, a global calculation can be performed to determine the decision.

4.5. Priority Order and Alternative Decision

Determination of the order of priorities and alternative decisions is obtained from the order of weights that have been normalized. The results of the global priority order are shown in Table 10.

Table 10: Results of Alternative Global Priority Order

	Criteria	K_1	K_2	K_3	K_4	K_5	Results
Normalize Weights (W_i) Criteria		0.135	0.156	0.178	0.453	0.253	
Alternative	Odong-odong	0.627	0.163	0.446	0.488	0.261	0.431
	Easy Bike	0.111	0.08	0.168	0.203	0.578	0.194
	Conventional motorcycle taxi	0.083	0.279	0.106	0.091	0.067	0.12
	Online motorcycle taxi	0.179	0.47	0.281	0.217	0.095	0.253

Based on Table 10, it is found that Odong-Odong is the first order, then online motorcycle taxis in the second order, conventional motorcycle taxis in the third order, and Easy Bike in the last order.

5. Conclussion

In this study, the best decision was determined in choosing the mode of transportation at the Jatinangor Campus Unpad using the Fuzzy Analytic Hierarchy Process (FAHP), with the alternatives used being Odong-Odong, Easy Bike, conventional motorcycles taxis, and online motorcycles taxis, as well as the criteria considered including tariff, time, comfort, safety, and environmental responsibility. Based on this research, it was found that Odong-Odong is the best mode of transportation that can be used at Unpad Jatinangor. For further research, it is recommended to use other Fuzzy Numbers, such as Trapezoidal Fuzzy Numbers or Gaussian Fuzzy Numbers to obtain more objective results.

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