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Application Of Mamdani's Fuzzy Logic In Modeling The Prediction Of Drug Abuse Levels In Padang City

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ABSTRACT

Drug abuse is a problem that can be influenced by various interrelated factors. This study aims to apply Mamdani Fuzzy logic in predicting the level of drug abuse in Padang City based on several factors obtained from documentation and interviews. The input variables used consist of the Age of the Perpetrator, Environment, Socializing, Gender, and Family, while the output variable is the Level of Drug Abuse with Low and High categories. The research stages include data collection, determining variables and fuzzy sets, fuzzification, forming if-then rules, inference using the minimum operator, composition using the maximum operator, and defuzzification using the centroid method. A total of 64 fuzzy rules are used to connect the combination of input variables with the output. Testing is done through manual calculations and implementation using MATLAB. The test results show that the output categories from manual calculations and MATLAB are the same in three test data, namely High, High, and Low. These results indicate that the Mamdani Fuzzy method can be used in modeling the level of drug abuse based on the variables used.

Keywords: Fuzzy Mamdani, Drug Abuse, Prediction, MATLAB.

INTRODUCTION

Padang City is one of the main cities in West Sumatra Province, with high population mobility and social activity. As a center of government, education, and the economy, Padang's development has increased social interaction and the complexity of community life. This situation has also given rise to various social problems, including drug abuse, which can disrupt social stability and public security [1].

Drug abuse is the unauthorized use of substances or drugs containing narcotics or in violation of applicable regulations. This use can lead to dependency and impact physical, psychological, and social health. In Indonesia, the definition and provisions regarding narcotics are regulated in Law Number 35 of 2009 concerning Narcotics [2], [3].

Drug abuse impacts physical, psychological, and social health. These effects include nervous system and organ disorders, emotional disturbances, dependency, increased crime, decreased productivity, and disruption of family harmony[4].

According to the West Sumatra Central Statistics Agency (BPS), drug abuse cases in Padang City increased from 204 cases in 2021 to 241 cases in 2022, 310 cases in 2023, and 351 cases in 2024. Data for 2025 is not yet available, so the study used data up to 2024[5].

The types of narcotics frequently found include methamphetamine, marijuana, and ecstasy. In this study, the analysis did not differentiate by drug type, but focused on the general level of drug abuse[6].

The number of drug abuse cases in Padang City continues to rise. Current management efforts still focus on taking action after a problem occurs, while risk prediction to support prevention efforts

remains limited. Therefore, a method is needed to help determine the level of drug abuse risk in a measurable manner.

Advances in information technology are driving the use of Artificial Intelligence (AI) in various fields, including decision support systems. AI can help analyze data and generate decisions in problems involving many variables and uncertainty[7][8].

One AI method that can handle uncertainty is Mamdani Fuzzy Logic. This method uses IF-THEN rules to generate decisions based on several variables[9][10]. In this study, Mamdani Fuzzy Logic was used to model the level of drug abuse based on the perpetrator's age, environment, social circle, gender, and family. The output was classified into low and high categories[11].

Previous research has shown that Mamdani Fuzzy Logic can be used to measure online gaming addiction levels among students in Ende Regency. This method is capable of processing uncertain data and generating decisions through IF-THEN rules[12].

This study aims to apply the Mamdani Fuzzy Logic method to model the level of drug abuse in Padang City as a decision-making support. This study is entitled "Application of Mamdani Fuzzy Logic in Modeling Prediction of Drug Abuse Levels in Padang City."

METHODOLOGY

The research stages are arranged systematically starting from problem formulation, literature study, data collection, designing the Mamdani Fuzzy model, testing using MATLAB, to drawing conclusions.

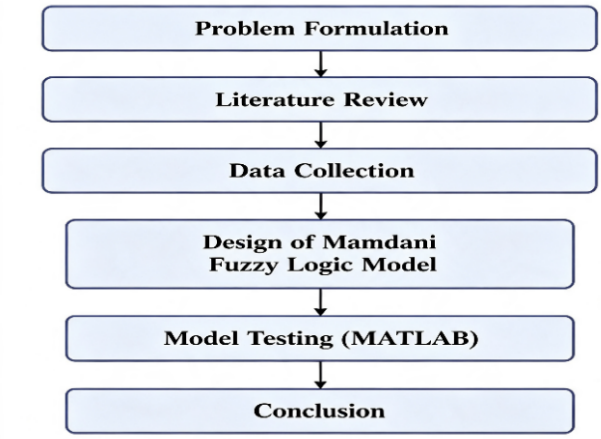

Figure 1. Research Design

A. Formulation of the problem

Problem formulation is the initial stage in determining the research problem based on the conditions of drug abuse in Padang City. This stage serves as the basis for determining the method, data collection, and designing the Fuzzy Mamdani prediction model.

B. Literature Study

A literature review was conducted by examining books, journal articles, undergraduate theses, legal regulations, and previous research related to Fuzzy Mamdani, prediction systems, and drug abuse. This review serves as a theoretical foundation and to determine the research's position and contribution.

C. Data retrieval

Research data was obtained from the Padang City Police Department (Polresta) through interviews and documentation. Interviews were conducted to obtain information on conditions, case developments, and factors influencing drug abuse. Documentation was used to obtain statistical data, reports, archives, and other supporting documents.

The data obtained are used to determine research variables, domains, membership function parameters, and fuzzy rules.

D. Mamdani Fuzzy Logic Model Design

Model design was carried out by determining input and output variables based on research data. Next, fuzzy sets, membership functions, fuzzification, inference, aggregation, and defuzzification were determined. The resulting model was then tested using MATLAB.

1. Fuzzification: mapping crisp values into fuzzy sets $\mathcal{X} \rightarrow [0, 1]$
2. Inference: calculating firing strength using the minimum operator

$$\alpha_i = \min(\mu_{\mathrm{A}}(\mathcal{X}), \mu_{\mathrm{B}}(y), \dots)$$

3. Aggregation: combining rule outputs using the maximum operator

$$\mu_{Output^{(z)}} = max(a_1, a_2, \dots, a_n)$$

4. Defuzzification: computing a crisp output value using the centroid formula

$$z^* = \frac{\int z \cdot \mu_z(z) dz}{\int \mu_z(z) dz}$$

The purpose of model design is to create a decision-making mechanism capable of processing uncertain data into more understandable information. The result of this stage is a Mamdani Fuzzy Logic model ready for testing using MATLAB software.

Table1. Fuzzy Set of Variables

Variables	Type	Fuzzy Set
Age of the Perpetrator	Input	Teenager
		Early Adulthood
		Productive Adults
		Late Adulthood
Environment		Safe
		Vulnerable
Socializing		Supervised
		Free
Gender		Woman
		Man
Family		Attention
		Lack of Attention
Drug Abuse Level	Output	Low
		High

1. Triangular Membership Function

A curve that has three parameters that form a triangular curve with one vertex. The membership formula is, namely.

2. Trapezoidal Membership Function

A curve with four parameters with a flat center indicating full membership. The membership formula is, namely.

Formula1Triangle Membership

$$\mu_x = \begin{cases} 0 & ; \quad x \leq a \; or \; x \geq c \\ \dfrac{x-a}{b-a} & ; \quad a \leq x \leq b \\ \dfrac{c-x}{c-b} & ; \quad b \leq x \leq c \end{cases}$$

Formula 2 Trapezoid Membership

$$\mu_x = \begin{cases} 0 & ; \\ \dfrac{x-a}{b-a} & x \leq a \; or \; x \geq d \\ \dfrac{d-x}{d-c} & a \leq x \leq b \\ 1 & b \leq x \leq c \\ & c \leq x \leq d \\ & ; \end{cases}$$

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E. Model Testing

Testing was conducted using data from the research dataset. From the entire dataset, several data points were used as test data to determine the compatibility of the manual Mamdani Fuzzy calculation results with the results processed using MATLAB. The test data was then processed through fuzzification, inference, aggregation, and defuzzification stages.

Table 2. Research Dataset

No	Age of the Perpetrator	Environment	Socializing	Gender	Family
1	15	76	57	1	50
2	12	81	75	0	49
3	14	46	49	1	43
4	15	48	72	0	56
5	14	78	66	1	43
6	12	45	59	0	61
7	12	47	66	1	60
8	15	75	51	0	47
9	16	68	48	1	63
10	15	55	61	1	46
11	13	85	67	1	52
12	16	73	69	0	62
13	17	43	59	1	51
14	14	77	72	1	45
15	13	77	55	1	46
16	17	86	67	0	55
17	12	49	67	1	47
18	14	67	62	1	52
19	13	80	62	1	48
20	16	75	53	0	42

The table presents some of the research data. The dataset consists of over 600 data points and is used as the basis for model development and testing.

F. Conclusion

The conclusion stage is the final stage of the research, which summarizes all the results obtained during the research process. The conclusions are based on data collection, the design of the Mamdani Fuzzy Logic model, model testing using MATLAB, and the implementation of the website-based system.

This stage will determine the extent to which the research objectives have been achieved and whether the applied Mamdani Fuzzy Logic model can assist in determining the level of drug abuse based on the input variables. Furthermore, the results of this study can serve as a reference for further research in developing fuzzy logic-based prediction systems.

RESULTS AND DISCUSSION

A. Fuzzy Set

Once the dataset has been determined, the next step is to define fuzzy sets for each variable used in the study. Fuzzy sets serve to group input values into linguistic categories so they can be processed using the Mamdani Fuzzy Method.

Table 3. Fuzzy Set

Variable Name	Universe of Discourse	Fuzzy Set	Curve	Domain
Age of the Perpetrator	[12–50]	Teenager	Trapezoid	[12 12 17 20]
		Early Adulthood	Triangle	[18 22 27]
		Productive Adults	Triangle	[25 31 37]
		Late Adulthood	Trapezoid	[35 42 50 50]
Environment	[0–90]	Safe	Triangle	[0 25 50]
		Vulnerable	Triangle	[35 65 90]
Socializing	[0–75]	Supervised	Triangle	[0 20 45]
		Free	Triangle	[30 55 75]
Gender	[0–1]	Woman	Trapezoid	[0 0 0.1 0.5]
		Man	Trapezoid	[0.4 0.7 1 1]
Family	[0–65]	Attention	Triangle	[0 15 40]
		Lack of Attention	Triangle	[20 50 65]
Drug Abuse Level	[0–76]	Low	Triangle	[0 10 35]
		High	Triangle	[25 55 76]

The following discussion of the membership functions of each set of variables is explained below.

1) Age of the Perpetrator

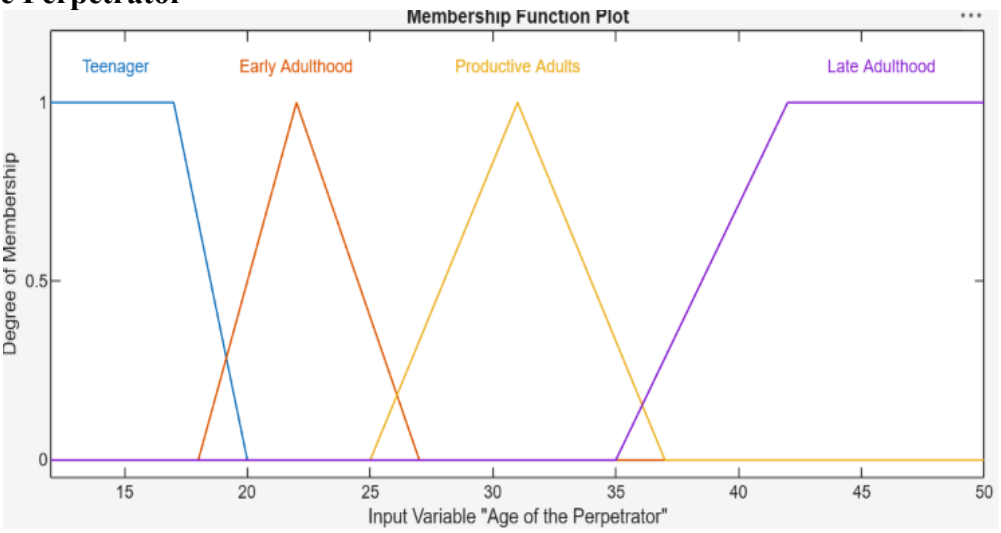

Figure 2. Age of the Perpetrator

a. Teenager [12 12 17 20]

$$\mu_{Teenager}{}^{x} = \begin{cases} 1 & ; \ 12 \le x \le 17 \\ \dfrac{20 - x}{20 - 17} & ; \ 17 < x < 20 \\ 0 & ; \ x \ge 20 \end{cases}$$

b. Early Adulthood [18 22 27]

$$\mu_{EarlyAdulthood}{}^{x} = \begin{cases} 0 & ; \ x \le 18 \\ \dfrac{x - 18}{22 - 18} & ; \ 18 < x \le 22 \\ \dfrac{27 - x}{27 - 22} & ; \ 22 < x < 27 \\ 0 & ; \ x \ge 27 \end{cases}$$

c. Productive Adults [24 31 37]

$$\mu_{ProductiveAdults}{}^{x} = \begin{cases} 0 & ; \ x \le 25 \\ \dfrac{x - 25}{31 - 25} & ; \ 25 < x \le 31 \\ \dfrac{37 - x}{37 - 31} & ; \ 31 < x < 37 \\ 0 & ; \ x \ge 37 \end{cases}$$

d. Late Adulthood [35 42 50 50]

$$\mu_{LateAdulthood}{}^{x} = \begin{cases} 0 & ; \ x \le 35 \\ \dfrac{x - 35}{42 - 35} & ; \ 35 < x < 42 \\ 1 & ; \ 42 \le x \le 50 \end{cases}$$

2) Environment

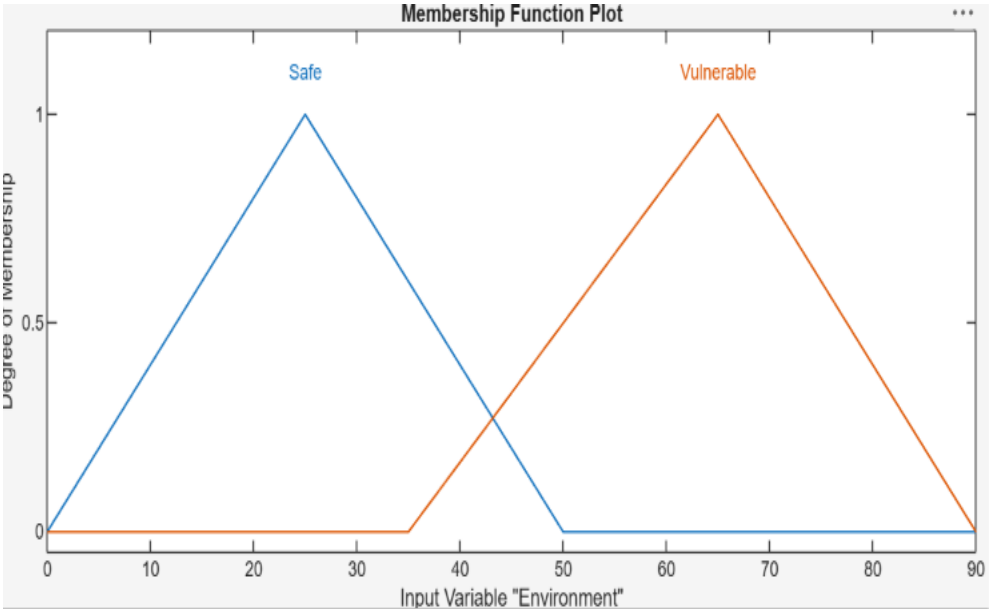

Figure 3. Environment

a. Safe [0 25 50]

$$\mu_{Safe}{}^{x} = \begin{cases} 0 & ; \ x \le 25 \\ \dfrac{x}{25} & ; \ 25 < x < 50 \\ \dfrac{50 - x}{25} & ; \ x \ge 50 \\ 0 & \end{cases}$$

b. Vulnerable [35 65 90]

$$\mu_{Vulnerable^x} = \begin{cases} 0 & ; \\ \dfrac{x-35}{65-35} & ; \ 35 < x \leq 65 \\ \dfrac{90-x}{90-65} & ; \ 65 < x < 90 \\ 0 & ; \end{cases} \quad x \leq 35 \quad x \geq 90$$

3) Socializing

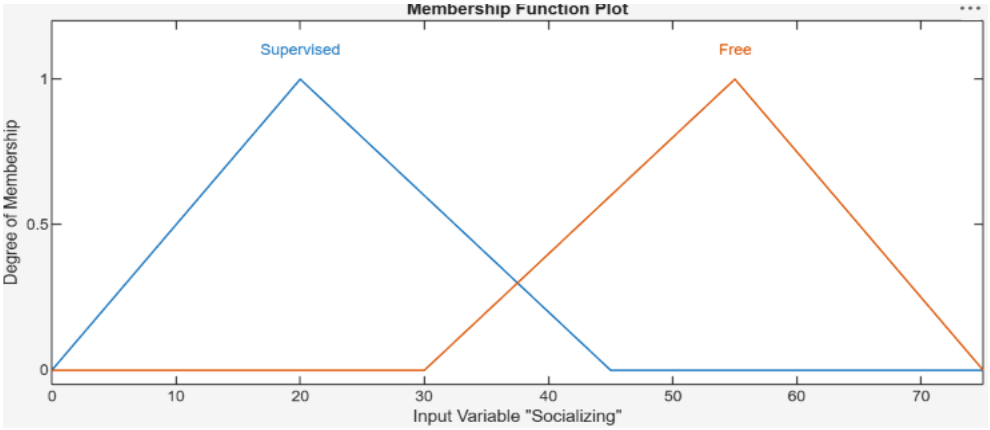

Figure 4. Socializing

a. Supervised [0 20 45]

$$\mu_{Supervised^x} = \begin{cases} 0 & ; \\ \dfrac{x}{20} & ; \ 20 < x < 45 \\ \dfrac{45-x}{25} & ; \\ 0 & ; \end{cases} \quad x \leq 20 \quad x \geq 45$$

b. Free [30 55 75]

$$\mu_{Free^x} = \begin{cases} 0 & ; \\ \dfrac{x-30}{25} & ; \ 30 < x \leq 55 \\ \dfrac{75-x}{20} & ; \ 55 < x < 75 \\ 0 & ; \end{cases} \quad x \leq 30 \quad x \geq 75$$

4) Gender

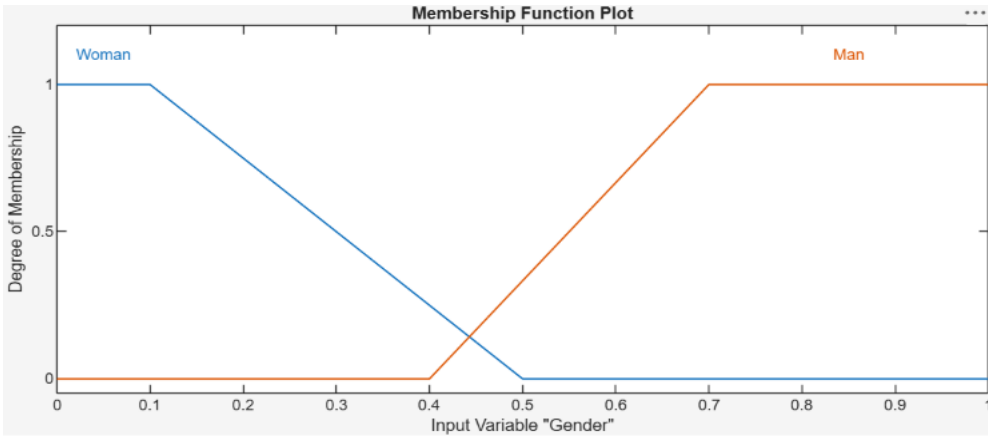

Figure 5. Gender

a. Woman [0 0 0.1 0.5]

$$\mu_{Woman^x} = \begin{cases} 1 & ; \quad x \leq 0.1 \\ \dfrac{0.5 - x}{0.5 - 0.1} & ; \quad 0.1 < x < 0.5 \\ 0 & ; \quad x \geq 0.5 \end{cases}$$

b. Man [0.4 0.7 1 1]

$$\mu_{Man^x} = \begin{cases} 0 & ; \quad x \leq 0.4 \\ \dfrac{x - 0.4}{0.7 - 0.4} & ; \quad 0.4 < x < 0.7 \\ 1 & ; \quad x \geq 1 \end{cases}$$

5) Family

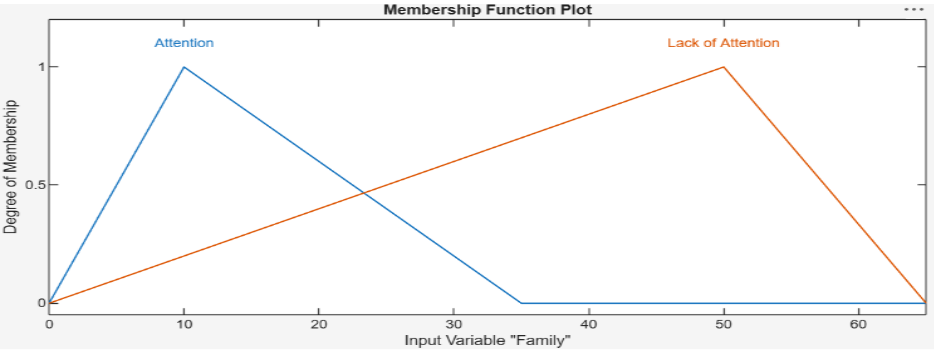

Figure 6. Family

a. Attention [0 15 40]

$$\mu_{Attention^x} = \begin{cases} 0 & ; \quad x \leq 0 \\ \dfrac{x}{15} & ; \quad 0 < x < 15 \\ \dfrac{40 - x}{40 - 15} & ; \quad 15 \leq x < 40 \\ 0 & ; \quad x \geq 40 \end{cases}$$

b. Lack of Attention [20 50 65]

$$\mu_{Lack of Attention^x} = \begin{cases} 0 & ; \quad x \leq 20 \\ \dfrac{x - 20}{50 - 20} & ; \quad 20 < x \leq 50 \\ \dfrac{65 - x}{65 - 50} & ; \quad 50 < x < 65 \\ 0 & ; \quad x \geq 65 \end{cases}$$

6) Output Drug Abuse Level

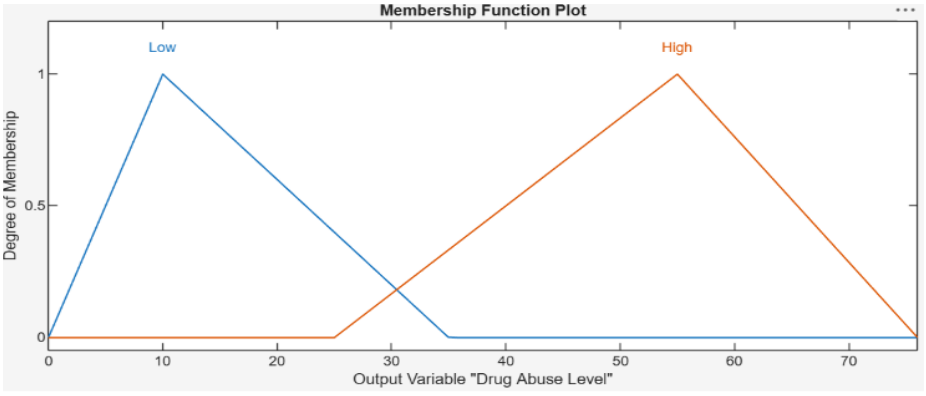

Figure 7. Drug Abuse Level

a. Low [0 10 35]

$$\mu_{Low^x} = \begin{cases} 0 & ; \\ \dfrac{z}{10} & ; \ z \leq 10 \\ \dfrac{35 - z}{35 - 10} & ; \ 0 < z < 10 \\ 0 & ; \ 10 \leq z < 35 \\ & ; \ z \geq 35 \end{cases}$$

b. High [25 55 76]

$$\mu_{High^x} = \begin{cases} 0 & ; \\ \dfrac{z - 25}{55 - 25} & ; \ z \leq 25 \\ \dfrac{76 - z}{76 - 55} & ; \ 25 < z < 55 \\ 0 & ; \ 55 \leq z \leq 76 \\ & ; \ z \geq 76 \end{cases}$$

The membership function calculation results for this variable indicate the degree of membership in the Low and High. This value serves as the basis for the next step in obtaining the final output value of the system.

B. Rule Base

After the membership function is determined, the next step is to develop a rule base. This study obtained 64 IF–THEN rules that are used as the basis for the inference process in the Mamdani Fuzzy method. The 64 rule bases are:

[R1] IF (Age of the Perpetrator is Teenager) AND (Environment is Safe) AND (Socializing is Supervised) AND (Gender is Woman) AND (Family is Attention) THEN (Drug Abuse Level is Low)

[R2] IF (Age of the Perpetrator is Teenager) AND (Environment is Safe) AND (Socializing is Supervised) AND (Gender is Woman) AND (Family is Lack of Attention) THEN (Drug Abuse Level is Low)

[R3] IF (Age of the Perpetrator is Teenager) AND (Environment is Safe) AND (Socializing is Supervised) AND (Gender is Man) AND (Family is Attention) THEN (Drug Abuse Level is Low)

[R4] IF (Age of the Perpetrator is Teenager) AND (Environment is Safe) AND (Socializing is Supervised) AND (Gender is Man) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R5] IF (Age of the Perpetrator is Teenager) AND (Environment is Safe) AND (Socializing is Free) AND (Gender is Woman) AND (Family is Attention) THEN (Drug Abuse Level is Low)

[R6] IF (Age of the Perpetrator is Teenager) AND (Environment is Safe) AND (Socializing is Free) AND (Gender is Woman) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R7] IF (Age of the Perpetrator is Teenager) AND (Environment is Safe) AND (Socializing is Free) AND (Gender is Man) AND (Family is Attention) THEN (Drug Abuse Level is High)

[R8] IF (Age of the Perpetrator is Teenager) AND (Environment is Safe) AND (Socializing is Free) AND (Gender is Man) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R9] IF (Age of the Perpetrator is Teenager) AND (Environment is Vulnerable) AND (Socializing is Supervised) AND (Gender is Woman) AND (Family is Attention) THEN (Drug Abuse Level is Low)

[R10] IF (Age of the Perpetrator is Teenager) AND (Environment is Vulnerable) AND (Socializing is Supervised) AND (Gender is Woman) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R11] IF (Age of the Perpetrator is Teenager) AND (Environment is Vulnerable) AND (Socializing is Supervised) AND (Gender is Man) AND (Family is Attention) THEN (Drug Abuse Level is High)

[R12] IF (Age of the Perpetrator is Teenager) AND (Environment is Vulnerable) AND (Socializing is Supervised) AND (Gender is Man) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R13] IF (Age of the Perpetrator is Teenager) AND (Environment is Vulnerable) AND (Socializing is Free) AND (Gender is Woman) AND (Family is Attention) THEN (Drug Abuse Level is High)

[R14] IF (Age of the Perpetrator is Teenager) AND (Environment is Vulnerable) AND (Socializing is Free) AND (Gender is Woman) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R15] IF (Age of the Perpetrator is Teenager) AND (Environment is Vulnerable) AND (Socializing is Free) AND (Gender is Man) AND (Family is Attention) THEN (Drug Abuse Level is High)

[R16] IF (Age of the Perpetrator is Teenager) AND (Environment is Vulnerable) AND (Socializing is Free) AND (Gender is Man) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R17] IF (Age of the Perpetrator is Early Adulthood) AND (Environment is Safe) AND (Socializing is Supervised) AND (Gender is Woman) AND (Family is Attention) THEN (Drug Abuse Level is Low)

[R18] IF (Age of the Perpetrator is Early Adulthood) AND (Environment is Safe) AND (Socializing is Supervised) AND (Gender is Woman) AND (Family is Lack of Attention) THEN (Drug Abuse Level is Low)

[R19] IF (Age of the Perpetrator is Early Adulthood) AND (Environment is Safe) AND (Socializing is Supervised) AND (Gender is Man) AND (Family is Attention) THEN (Drug Abuse Level is Low)

[R20] IF (Age of the Perpetrator is Early Adulthood) AND (Environment is Safe) AND (Socializing is Supervised) AND (Gender is Man) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R21] IF (Age of the Perpetrator is Early Adulthood) AND (Environment is Safe) AND (Socializing is Free) AND (Gender is Woman) AND (Family is Attention) THEN (Drug Abuse Level is Low)

[R22] IF (Age of the Perpetrator is Early Adulthood) AND (Environment is Safe) AND (Socializing is Free) AND (Gender is Woman) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R23] IF (Age of the Perpetrator is Early Adulthood) AND (Environment is Safe) AND (Socializing is Free) AND (Gender is Man) AND (Family is Attention) THEN (Drug Abuse Level is High)

[R24] IF (Age of the Perpetrator is Early Adulthood) AND (Environment is Safe) AND (Socializing is Free) AND (Gender is Man) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R25] IF (Age of the Perpetrator is Early Adulthood) AND (Environment is Vulnerable) AND (Socializing is Supervised) AND (Gender is Woman) AND (Family is Attention) THEN (Drug Abuse Level is Low)

[R26] IF (Age of the Perpetrator is Early Adulthood) AND (Environment is Vulnerable) AND (Socializing is Supervised) AND (Gender is Woman) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R27] IF (Age of the Perpetrator is Early Adulthood) AND (Environment is Vulnerable) AND (Socializing is Supervised) AND (Gender is Man) AND (Family is Attention) THEN (Drug Abuse Level is High)

[R28] IF (Age of the Perpetrator is Early Adulthood) AND (Environment is Vulnerable) AND (Socializing is Supervised) AND (Gender is Man) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R29] IF (Age of the Perpetrator is Early Adulthood) AND (Environment is Vulnerable) AND (Socializing is Free) AND (Gender is Woman) AND (Family is Attention) THEN (Drug Abuse Level is High)

[R30] IF (Age of the Perpetrator is Early Adulthood) AND (Environment is Vulnerable) AND (Socializing is Free) AND (Gender is Woman) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R31] IF (Age of the Perpetrator is Early Adulthood) AND (Environment is Vulnerable) AND (Socializing is Free) AND (Gender is Man) AND (Family is Attention) THEN (Drug Abuse Level is High)

[R32] IF (Age of the Perpetrator is Early Adulthood) AND (Environment is Vulnerable) AND (Socializing is Free) AND (Gender is Man) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R33] IF (Age of the Perpetrator is Productive Adults) AND (Environment is Safe) AND (Socializing is Supervised) AND (Gender is Woman) AND (Family is Attention) THEN (Drug Abuse Level is Low)

[R34] IF (Age of the Perpetrator is Productive Adults) AND (Environment is Safe) AND (Socializing is Supervised) AND (Gender is Woman) AND (Family is Lack of Attention) THEN (Drug Abuse Level is Low)

[R35] IF (Age of the Perpetrator is Productive Adults) AND (Environment is Safe) AND (Socializing is Supervised) AND (Gender is Man) AND (Family is Attention) THEN (Drug Abuse Level is Low)

[R36] IF (Age of the Perpetrator is Productive Adults) AND (Environment is Safe) AND (Socializing is Supervised) AND (Gender is Man) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R37] IF (Age of the Perpetrator is Productive Adults) AND (Environment is Safe) AND (Socializing is Free) AND (Gender is Woman) AND (Family is Attention) THEN (Drug Abuse Level is Low)

[R38] IF (Age of the Perpetrator is Productive Adults) AND (Environment is Safe) AND (Socializing is Free) AND (Gender is Woman) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R39] IF (Age of the Perpetrator is Productive Adults) AND (Environment is Safe) AND (Socializing is Free) AND (Gender is Man) AND (Family is Attention) THEN (Drug Abuse Level is High)

[R40] IF (Age of the Perpetrator is Productive Adults) AND (Environment is Safe) AND (Socializing is Free) AND (Gender is Man) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R41] IF (Age of the Perpetrator is Productive Adults) AND (Environment is Vulnerable) AND (Socializing is Supervised) AND (Gender is Woman) AND (Family is Attention) THEN (Drug Abuse Level is Low)

[R42] IF (Age of the Perpetrator is Productive Adults) AND (Environment is Vulnerable) AND (Socializing is Supervised) AND (Gender is Woman) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R43] IF (Age of the Perpetrator is Productive Adults) AND (Environment is Vulnerable) AND (Socializing is Supervised) AND (Gender is Man) AND (Family is Attention) THEN (Drug Abuse Level is High)

[R44] IF (Age of the Perpetrator is Productive Adults) AND (Environment is Vulnerable) AND (Socializing is Supervised) AND (Gender is Man) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R45] IF (Age of the Perpetrator is Productive Adults) AND (Environment is Vulnerable) AND (Socializing is Free) AND (Gender is Woman) AND (Family is Attention) THEN (Drug Abuse Level is High)

[R46] IF (Age of the Perpetrator is Productive Adults) AND (Environment is Vulnerable) AND (Socializing is Free) AND (Gender is Woman) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R47] IF (Age of the Perpetrator is Productive Adults) AND (Environment is Vulnerable) AND (Socializing is Free) AND (Gender is Man) AND (Family is Attention) THEN (Drug Abuse Level is High)

[R48] IF (Age of the Perpetrator is Productive Adults) AND (Environment is Vulnerable) AND (Socializing is Free) AND (Gender is Man) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R49] IF (Age of the Perpetrator is Late Adulthood) AND (Environment is Safe) AND (Socializing is Supervised) AND (Gender is Woman) AND (Family is Attention) THEN (Drug Abuse Level is Low)

[R50] IF (Age of the Perpetrator is Late Adulthood) AND (Environment is Safe) AND (Socializing is Supervised) AND (Gender is Woman) AND (Family is Lack of Attention) THEN (Drug Abuse Level is Low)

[R51] IF (Age of the Perpetrator is Late Adulthood) AND (Environment is Safe) AND (Socializing is Supervised) AND (Gender is Man) AND (Family is Attention) THEN (Drug Abuse Level is Low)

[R52] IF (Age of the Perpetrator is Late Adulthood) AND (Environment is Safe) AND (Socializing is Supervised) AND (Gender is Man) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R53] IF (Age of the Perpetrator is Late Adulthood) AND (Environment is Safe) AND (Socializing is Free) AND (Gender is Woman) AND (Family is Attention) THEN (Drug Abuse Level is Low)

[R54] IF (Age of the Perpetrator is Late Adulthood) AND (Environment is Safe) AND (Socializing is Free) AND (Gender is Woman) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R55] IF (Age of the Perpetrator is Late Adulthood) AND (Environment is Safe) AND (Socializing is Free) AND (Gender is Man) AND (Family is Attention) THEN (Drug Abuse Level is High)

[R56] IF (Age of the Perpetrator is Late Adulthood) AND (Environment is Safe) AND (Socializing is Free) AND (Gender is Man) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R57] IF (Age of the Perpetrator is Late Adulthood) AND (Environment is Vulnerable) AND (Socializing is Supervised) AND (Gender is Woman) AND (Family is Attention) THEN (Drug Abuse Level is Low)

[R58] IF (Age of the Perpetrator is Late Adulthood) AND (Environment is Vulnerable) AND (Socializing is Supervised) AND (Gender is Woman) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R59] IF (Age of the Perpetrator is Late Adulthood) AND (Environment is Vulnerable) AND (Socializing is Supervised) AND (Gender is Man) AND (Family is Attention) THEN (Drug Abuse Level is High)

[R60] IF (Age of the Perpetrator is Late Adulthood) AND (Environment is Vulnerable) AND (Socializing is Supervised) AND (Gender is Man) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R61] IF (Age of the Perpetrator is Late Adulthood) AND (Environment is Vulnerable) AND (Socializing is Free) AND (Gender is Woman) AND (Family is Attention) THEN (Drug Abuse Level is High)

[R62] IF (Age of the Perpetrator is Late Adulthood) AND (Environment is Vulnerable) AND (Socializing is Free) AND (Gender is Woman) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

[R63] IF (Age of the Perpetrator is Late Adulthood) AND (Environment is Vulnerable) AND (Socializing is Free) AND (Gender is Man) AND (Family is Attention) THEN (Drug Abuse Level is High)

[R64] IF (Age of the Perpetrator is Late Adulthood) AND (Environment is Vulnerable) AND (Socializing is Free) AND (Gender is Man) AND (Family is Lack of Attention) THEN (Drug Abuse Level is High)

Each combination of inputs results in a decision on the level of drug abuse. Rules with a membership degree greater than zero become active rules and are processed using the MIN operator.

C. Testing

After the Fuzzy Mamdani model was formed, testing was carried out.

Table 4. Data Testing

Test Data	Variables				
	Age of the Perpetrator	Environment	Socializing	Gender	Family
220	24	84	68	1	42
320	25	48	46	1	57
496	39	2	9	1	17

1. Test Data 1

A. Fuzzification

1) Age of the Perpetrator

a. Teenager

Because $24 > 20$, the perpetrator's age value is outside the domain of the Teenage fuzzy set, so the degree of membership is:

$$\mu_{Teenager^{24}} = 0$$

b. Early Adulthood

Because $22 < x < 27$, then the equation for the descending side is used

$$\mu_{EarlyAdulthood^{24}} = \frac{27-24}{27-22} = \frac{3}{5} = 0.6$$

So , $\mu_{EarlyAdulthood^{24}} = 0.6$

c. Productive Adults

Because $24 < 25$, the perpetrator's age value is outside the domain of the Productive Adults fuzzy set, so the degree of membership is:

$$\mu_{ProductiveAdults^{24}} = 0$$

d. Late Adulthood

Because $24 < 35$, the perpetrator's age value is outside the domain of the Late Adulthood fuzzy set, so the degree of membership is:

$$\mu_{LateAdulthood^{24}} = 0$$

2) Environment

a. Safe

Because the neighborhood value of 84 is greater than the upper limit of the domain of the Safe fuzzy set, which is 50, then this value is outside the membership area of the Safe set.

So that, $\mu_{Safe^{84}} = 0$

b. Vulnerable

Because $65 < x < 90$, used down side

$$\mu_{Vulnerable^{84}} = \frac{90 - x}{90 - 65} = \frac{90 - 84}{25} = \frac{6}{25} = 0.24$$

So that, $\mu_{Vulnerable^{84}} = 0.24$

3) Socializing

a. Supervised

Since the association value of 68 is greater than the upper limit of the domain of the Supervised fuzzy set, which is 45, then this value is outside the membership area of the Supervised set. This, $\mu_{Supervised^{68}} = 0$

b. Free

Because, $55 < x < 75$, used down side

$$\mu_{Free^{68}} = \frac{75 - x}{75 - 75} = \frac{75 - 68}{20} = \frac{7}{20} = 0.35$$

So that, $\mu_{Free^{68}} = 0.35$

4) Gender

a. Woman

Because the gender value of 1 is greater than the upper limit of the domain of the Woman fuzzy set, which is 0.5, then this value is outside the membership area of the Woman set. So that, $\mu_{Woman^{1}} = 0$

b. Man

Because the gender value 1 is in the flat area (plateau) of the Man fuzzy set, namely in the domain $[0.7 - 1]$.

Then the degree of membership is full value. So that, $\mu_{Man^{1}} = 1$

5) Family

a. Attention

Since the family value of 42 is greater than the upper limit of the domain of the fuzzy set Attention, which is 40, then the value is outside the membership area of the fuzzy set Attention. So, $\mu_{Attention^{42}} = 0$

b. Lack of Attention

Because, $20 < x < 50$, used rising side

$$\mu_{LackofAttention^{42}} = \frac{x - 20}{50 - 20} = \frac{42 - 20}{30} = \frac{22}{30} = 0.73$$

So that, $\mu_{LackofAttention^{42}} = 0.73$

B. Inference

Since the other fuzzy sets have a value of 0, only rules that have all antecedents with a non-zero value will be active.

Based on the rule basis, the combination complies with Rule 32.

IF
Age of Perpetrator = Early Adulthood
AND Environment = Vulnerable
AND Socializing = Free
AND Gender = Man
AND Family = Lack of Attention
THEN Drug Abuse Level = High

Determining α-predicate:

Since the logical operator used in the Mamdani method is the AND (Minimum) operator, the α-predicate value of Rule 32 is calculated as follows. Thus,

$$\alpha 32 = min(0.6, 0.24, 0.35, 1.0, 0.73) = 0.24$$

Thus, only Rule 32 contributes to the inference process with an α-predicate value of 0.24.

C. Composition of Rules

Since only Rule 32 is active, the rule composition results are obtained by clipping the output membership function of High using the value α = 0.24.

The output membership function of High is:

Domain : [25 55 76]

Curve: Triangle

The membership function equation is

$$\mu_{High^z} = \begin{cases} 0 & ; \\ \dfrac{z-25}{30} & ; \ z \le 25 \\ \dfrac{76-z}{21} & ; \ 25 < z < 55 \\ 0 & ; \ 55 \le z < 76 \\ & ; \ z \ge 76 \end{cases}$$

Because the α-predicate is 0.24, the output membership function is clipped at a height of 0.24 so that the maximum value of the inference membership function becomes 0.24.

D. Defuzzification

Defuzzification is done to change the output fuzzy set results into crisp values. The inference results produce an α-predicate value of

$$\alpha = 0.24$$

so that the output membership function High is truncated at a height of 0.24.

The clipping point is obtained and $z1 = 32{,}2 z2 = 70.96$

So that the resulting composition function becomes

$$\mu_z = \begin{cases} \dfrac{z-25}{30} & ; \ 25 \le z \le 32.2 \\ 0.24 & ; \ 32.2 \le z \le 70.96 \\ \dfrac{76-z}{21} & ; \ 70.96 \le z \le 76 \end{cases}$$

Calculating the Area of a Region

Area 1

$$A_1 = \int_{25}^{32.2} \frac{z-25}{30}\,dz = \frac{1}{30}\int_{25}^{32.2} (z-25)\,dz = \frac{1}{30}\left[\frac{(z-25)^2}{2}\right]_{25}^{32.2}$$

$$= \frac{1}{30}\left(\frac{7.2^2}{2}\right) = 0.864$$

Area 2

$$A_2 = \int_{32.2}^{70.96} 0.24\,dz = 0.24(70.96 - 32.2) = 9.3024$$

Area 3

$$A_3 = \int_{70.96}^{76} \frac{76-z}{21}\,dz = \frac{1}{21}\left[76z - \frac{z^2}{z}\right]_{70.96}^{76} = 0.6048$$

Total Area

$$Area = A_1 + A_2 + A_3$$

$$= 0.864 + 9.3024 + 0.6048 = 10.7712$$

Calculation of Moments

Moments 1

$$M_1 = \int_{25}^{32.2} z\left(\frac{z-25}{30}\right)dz = \frac{1}{30}\int (z^2 - 25z)\,dz = \frac{1}{30}\left[\frac{z^3}{3} - \frac{25z^2}{2}\right]_{25}^{32.2}$$

Upper limit substitution

$$F(32.2) = \frac{32.2^3}{3} - \frac{25(32.2)^2}{2} = \frac{33386.248}{3} - \frac{25(1036.84)}{2} = 11128.74933 - 12960.50$$
$$= -1831.75067$$

Lower limit substitution

$$F(25) = \frac{25^3}{3} - \frac{25(25)^2}{2} = \frac{15625}{3} - \frac{15625}{2} = 5208.33333 - 7812.50 = -2604.16667$$
$$F(32.2) - F(25) = (-1831.75067) - (-2604.166667) = -1831.75067 + 2604.16667$$
$$= 772.41600$$
$$= \frac{772.41600}{30} 24.5376$$

So that, $M_1 = 24.5376$

Moments 2

$$M_2 = \int_{32.2}^{70.96} 0.24_z \, dz = 0.24 \left[\frac{z^2}{2}\right]_{32.2}^{70.96} = 0.12(70.96^2 - 32.2^2) = 480.5505$$

Moments 3

$$M_3 = \int_{70.96}^{76} z\left(\frac{76 - z}{21}\right) dz = \frac{1}{21}\int (76z - z^2)\, dz$$
$$= \frac{1}{21}\left[38z^2 - \frac{z^3}{3}\right]_{70.96}^{76} = 43.6114$$

Total Moments

$$Moments = M_1 + M_2 + M_3$$
$$= 24.5376 + 480.5505 + 43.6114 = 548.6995$$

Crisp Value

$$Z^* = \frac{M}{A} = \frac{548.6995}{10.7712} = 50.94$$

So the result of defuzzification is $z^* = 50.94$

Based on the area and moment of area calculations for the composition, a crisp value of 50.94 was obtained. This value was then used to determine the level of drug abuse. The result was categorized as High.

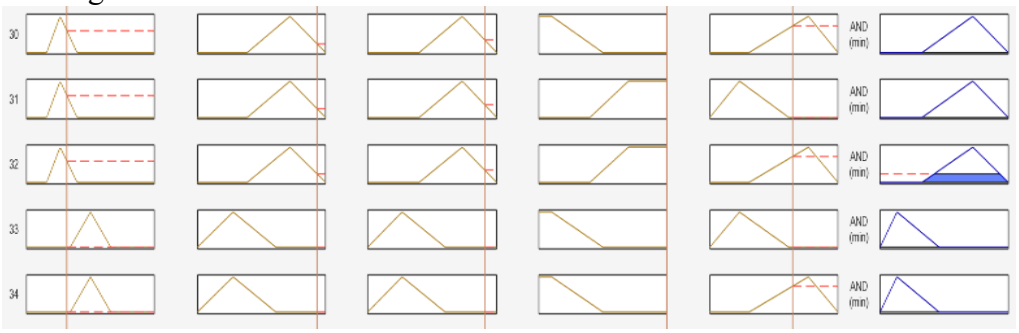

Figure 8. Rule Inference Data Test 1

The MATLAB results show the active rules and firing strength values composed using the MAX operator. The resulting crisp values are consistent with the manual calculations.

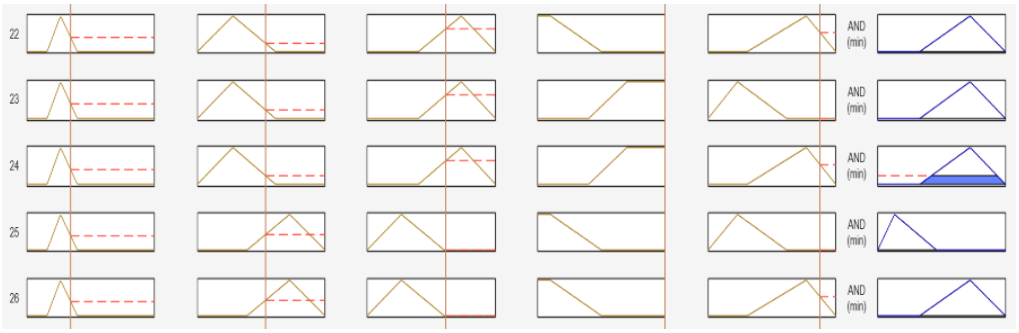

Figure 9. Rule Inference Test Data 2 Rule Base 24

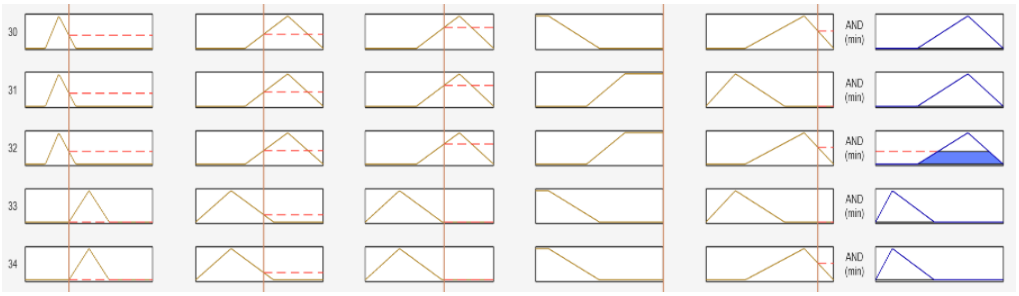

Figure 10. Rule Inference Test Data 2 Rule Base 32

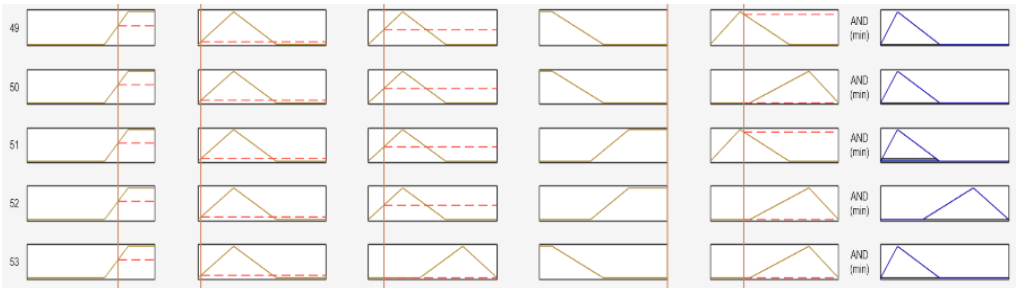

Figure 11. Rule Inference Data Test 3

The figure shows the Rule Viewer results for the three test cases. Each test case activates a specific fuzzy rule based on the combination of input values. The aggregated output from these active rules is then used in the defuzzification process to calculate the final drug abuse level score.

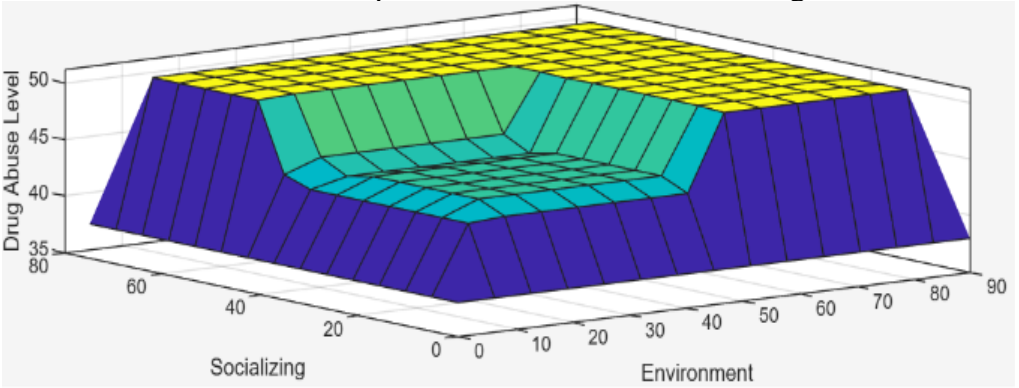

Figure 12. Surface Viewer

The surface graph shows the relationship between the environmental and social variables and the level of drug abuse. The surface graph shows changes in output values based on the combination of the two input variables.

D. Test Results

Table 5. Test Results

No	Test Data	Manual Results	MATLAB Results	Difference	Information
1	Test Data 220	50.94	51	0.06	High
2	Test Data 320	51.30	51.30	0.00	High
3	Test Data 496	17.20	17.20	0.00	Low

Test Data 1 produces a value of 50.94 manually and 51.00 in MATLAB with a difference of 0.06. Test Data 2 produces a value of 51.30 in both methods, while Test Data 3 produces a value of 17.20. The difference in Test Data 1 is caused by the numerical accuracy in the defuzzification process. Although there are differences in the values in Test Data 1, all data produce the same categories, namely High, High, and Low. While this study presents detailed verification across three representative cases, future studies should extend evaluation across the full dataset of over 600 records to report aggregate performance metrics such as Mean Absolute Error and overall classification accuracy.

CONCLUSION

Based on the test results, the Fuzzy Mamdani method can be used to determine the level of drug abuse based on the variables used. Test Data 1 produces a value of 50.94 manually and 51.00 in MATLAB with a difference of 0.06. Test Data 2 produces a value of 51.30 and Test Data 3 is 17.20 in both methods. The resulting categories are the same in all test data, namely High in Test Data 1 and 2 and Low in Test Data 3. These results indicate that the Fuzzy Mamdani model provides consistent output between manual calculations and MATLAB.

REFERENCES

[1] D. M. Pahutar, L. Lindayanti, and N. Nopriyasman, “The relationship between settlements and modes of transportation in Padang City, 1957–2017,” Titian Journal of Humanities, vol. 5, no. 1, pp. 25–43, 2021, doi: 10.22437/titian.v5i1.11870.

[2] Sawirman, “The role of the West Sumatra Regional Narcotics Directorate in preventing narcotics and psychotropic substance abuse among students in Padang City,” Ekasakti Journal of Research and Community Service, vol. 3, no. 1, pp. 74–83, 2022. [Online]. Available: https://www.academia.edu/download/82788909/321.pdf

[3] W. Hariyadi and T. Anindito, “Implementation of assessment for narcotics abuse offenders reviewed from Law No. 35 of 2009 concerning narcotics,” Jurnal Pendidikan Kewarganegaraan Undiksha, vol. 9, no. 2, pp. 377–383, 2021. [Online]. Available: https://ejournal.undiksha.ac.id/index.php/JJPP/article/view/34140

[4] A. Kadarmanta and Effriyanti, “The impact of drug abuse on social and economic aspects in the DKI Jakarta Province,” Bulletin Journal of Multidisciplinary Science, vol. 1, no. 4, pp. 729–735, 2022.

[5] V. E. Suryani, M. R. Azmy, and W. D. Putri, Padang Municipality in Figures 2026, vol. 47, 2026.

[6] A. R. A. Shany, Y. Saefudin, and N. Ismail, “UMPurwokerto Law Review,” Journal of UMPurwokerto Law Review, vol. 5, no. 2, pp. 11–20, 2025, doi: 10.30595/umplr.v5i2.27124.

[7] M. Atika and R. Sayekti, “Artificial intelligence (AI)-based library information systems: A literature review,” N. Journal of Information and Library Science, vol. 14, no. 1, pp. 39–52, 2023. [Online]. Available: https://e-journal.unair.ac.id/palimpsest/article/view/46405

[8] Rita Tri Wulandari, Ummi Syafiqoh, and M. Hafid, "Implementation of Mamdani fuzzy logic in determining product order quantities at PT Forisa Nusapersada Tarakan Area," Journal of Big Data Analytics and Artificial Intelligence, vol. 6, no. 1, pp. 19–25, 2023, doi: 10.71302/jbidai.v6i1.44.

[9] D. Kurniadi, F. Nuraeni, and D. Jaelani, "Implementation of Mamdani fuzzy logic in a prediction system for prospective recipients of the Family Hope Program," Jurnal Algoritma, vol. 19, no. 1, pp. 151–162, 2022, doi: 10.33364/algoritma/v.19-1.1016.

[10] H. Munte, Apip Pramudyansyah, and Umryah, "Comparison of Mamdani fuzzy and Sugeno fuzzy methods for employee performance evaluation (case study: XYZ law firm)," Computatio: Journal of Computer Science and Information Systems, vol. 8, no. 1, pp. 1–12, 2024, doi: 10.24912/computatio.v8i1.11705.

[11] E. J. Aenun and Mashuri, "Implementation of Mamdani fuzzy logic method for predicting electricity usage costs," Unnes Journal of Mathematics, vol. 11, no. 2, 2022, doi: 10.15294/ujm.v11i2.50061

[12] L. A. F. Dewa and A. S. Purnomo, "Application of Mamdani fuzzy logic method to identify the level of online game dependency among students in Ende Regency," Journal of Informatics and Information Systems Engineering, vol. 11, no. 4, pp. 90–102, 2024.