

## Application of Fuzzy Logic in Predicting Grocery Store Revenue

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### ABSTRACT

**Objective:** This study aims to predict grocery store income accurately using the **Mamdani fuzzy logic method** to address challenges caused by **price fluctuations** and **market uncertainty** in retail operations. **Method:** Data were collected through direct observation at a grocery store in **Sidoarjo** over one month, including variables such as the **number of items sold**, **total price**, and **operational costs**. Each variable was classified into fuzzy sets using **triangular and shoulder-shaped membership functions**. The fuzzy inference system consisted of **27 if-then rules**, with output values determined through the **Weighted Average defuzzification method**. **Results:** Based on input data of **1,004 units sold**, a **total price of Rp. 14,124,500**, and **operational costs of Rp. 4,500,000**, the system successfully predicted an income of **Rp. 10,000,000**. Evaluation using **Mean Absolute Percentage Error (MAPE)** indicated an **error rate of 0%**, signifying exceptional predictive accuracy. **Novelty:** The study demonstrates that fuzzy logic can serve as a **highly effective decision-support tool** for income prediction in small-scale retail businesses, providing a reliable framework for managing financial uncertainty.

## INTRODUCTION

Grocery stores, as daily retail businesses, face the challenges of price fluctuations, seasonality, and market dynamics. This uncertainty requires a predictive approach capable of handling ambiguous data, for which fuzzy logic provides a solution due to its ability to model uncertainty through membership degrees [1]. This study applies fuzzy logic to predict grocery store revenue to improve planning accuracy and reduce operational risk.

Previous studies have demonstrated the success of fuzzy logic in sales prediction [2] and production optimization [3], but these are generally limited to price and volume variables without considering operational costs or external factors such as seasonality. Validation is also often limited, raising questions about scalability. This study uses Mamdani's method to address these limitations by adding new variables and testing based on long-term data [4].

The aim of this research is to develop an accurate and reliable Mamdani fuzzy model in predicting grocery store income, as well as to evaluate its scalability in various business scenarios.

## RESEARCH METHOD

### 1. Data collection

In this study, data was collected directly from a grocery store located at Jl. Sunandar PS No. 85, Sidokare, Sidoarjo. Data collection was conducted over a period of one month by recording all transaction activities, including items sold, price per item, discounts (if any), and total daily sales. In addition, the store owner was also asked for information on operational costs, such as electricity, water, transportation, and other routine expenses. The data collection process was carried out through brief interviews with the store manager and manual recording using a cash book and store accounting documents. This ensures that the data obtained is accurate and in accordance with the actual conditions of the business. To minimize errors, each record was double-checked before further analysis.

### 2. Fuzzyfication

Fuzzyfication is the process of converting numbers into representations in fuzzy sets accompanied by determining their membership values [5]. This study uses three variables as input, namely the number of items sold, the price of the item, and operational costs, while the output analyzed is the amount of income. Both input and output variables are represented through several fuzzy sets that reflect their linguistic values [6]. To assist the process of determining the degree of membership, researchers apply shoulder and triangle curves [7]. These two types of curves simplify the representation with increasing and decreasing linear patterns. The degree of membership in each variable is calculated using the shoulder and triangle curves.

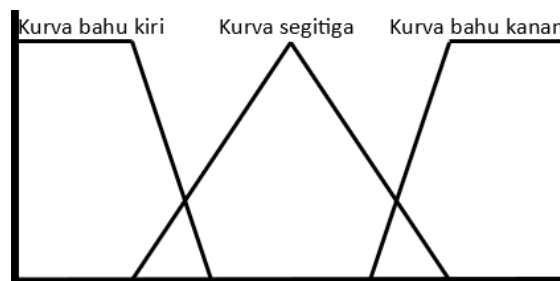


Figure 1 Curve

#### a. Shoulder Curve and Triangle Representation

- 1) The membership function that describes the shape of the left shoulder curve:

$$\mu(x) = \begin{cases} 0, & x \geq b \\ \frac{b-x}{b-a}, & a \leq x \leq b \\ 1, & x \leq a \end{cases}$$

- 2) The membership function that describes the shape of the right shoulder curve:

$$\mu(x) = \begin{cases} 0, & x \leq a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ 1, & x \geq b \end{cases}$$

- 3) Membership function that describes the shape of the Triangular curve:

$$\mu(x) \begin{cases} 0, & x \leq a \text{ atau } x \geq c \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ 1, & x = b \\ \frac{c-x}{c-b}, & b \leq x \leq c \end{cases}$$

### 3. Fuzzy Rules

In a fuzzy logic system, rules explain the relationship between variables through a linguistic approach, derived from various existing data. Fuzzy rules are applied in an if-then format on fuzzy sets, using operators such as 'OR', 'AND', and 'NOT' [8]. This study developed 27 rules based on predetermined variables and language categories. The three input variables used are the number of items sold, the price of the items, and operational costs. Each variable has a linguistic value divided into three categories: low, medium, and high for the number of items sold; low, medium, and high for the price of the items; and low, medium, and high for operational costs. Meanwhile, income is grouped into low, medium, and high categories.

### 4. Fuzzy Inference

The fuzzy inference process is used to evaluate the rules relevant to the given input, by determining the degree of membership of each input to its linguistic category [9]. Inference is carried out using the Mamdani method, namely by calculating the rule strength (firing strength) using the MIN operator in the AND condition, then producing a fuzzy output that is truncated according to the value of the membership degree [10]. All outputs from active rules are then combined through an aggregation process using the MAX operator, and the final result is determined through a defuzzification process.

### 5. Defuzzification

The defuzzification process is the final step that converts the fuzzy output (membership degree) into a definite income value or crisp value [11]. In this study, income defuzzification in a grocery store uses the Weighted Average method.

$$WA = \frac{a_1 * z_1 + a_2 * z_2 + \dots + a_n * z_n}{a_1 + a_2 + \dots + a_n}$$

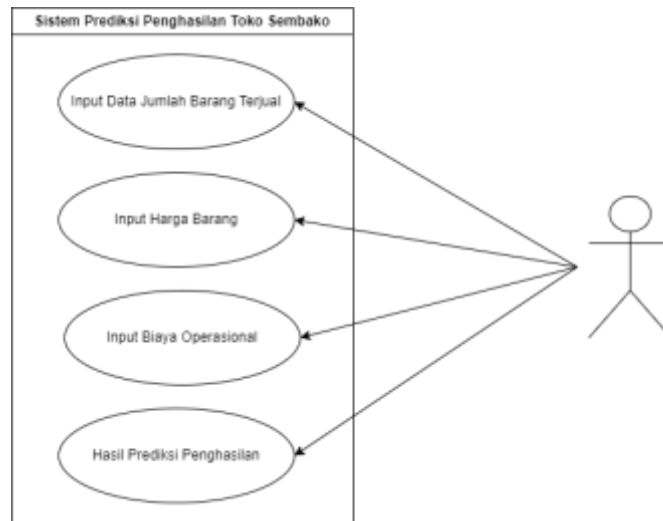
Information :

WA = average

$a_n$  = predicate of the *n*th rule

$z_n$  = index of output value (constant) *n*th .

## 6. System Design



**Figure 2** Use Case Diagram

In the application of fuzzy logic, use case diagrams are utilized to visualize the interaction between users and systems, particularly in the context of control systems and decision support systems [8]. The design of this grocery store revenue prediction system includes several key components to generate accurate revenue estimates. This system receives input data on the number of items sold, the price of the items, and operational costs as the basis for calculations. By processing this data, the system then produces revenue predictions that can assist store owners in financial planning, stock management, and business decision-making. This approach allows for more measurable predictions, especially in dealing with price fluctuations and market dynamics that often occur in grocery retail businesses.

## RESULTS AND DISCUSSION

### A. Research Data

The following are the results of the data received:

#### a. Grocery Store Prices

**Table 1** Grocery Store Prices

No	Product name	Unit	Price (IDR)
1	Rice	1 kg	15,000
2	LPG	1 kg	19,000
3	Cooking oil	1 liter	18,000
4	Sugar	1 kg	18,000
5	Chicken eggs	1 kg	28,000
6	Flour	1 kg	12,500
7	Robe Flour	1 sachet	2,500
8	Tapioca flour	1 sachet	8,000
9	Leaf Salt	1 sachet (500 g)	5,000
10	Medium Bottle Aqua	600 ml	3,000

No	Product name	Unit	Price (IDR)
11	Big Bottle Aqua	1,500 ml	6,000
12	Tea bag	1 box (25)	8,000
13	Red onion	1 kg	25,000
14	Garlic	1 kg	30,000
15	Red chili pepper	1 kg	40,000
16	Cayenne pepper	1 kg	50,000
17	Candlenut	1 kg	30,000
18	Coriander	1 kg	40,000
19	Instant Coconut Milk	1 pack	3,000
20	My Pepper	1 sachet	1,000
21	Masako	1 sachet	1,000
22	Royco	1 sachet	1,000
23	Rinso liquid	1 sachet	2,000
24	Soklin	1 sachet	2,000
25	Sunlight	1 sachet	2,500
26	molto	1 sachet	2,000
27	Giv Soap	1 stick	3,000
28	Dettol Soap	1 stick	3,000
29	Lux Soap	1 stick	4,000
30	Lifebuoy Soap	1 stick	5,000
31	Shampoo	1 sachet	2,000
32	Steamer	1 sachet	2,500
33	Tora Milk/Mocha	1 sachet	2,500
34	Dancow	1 sachet	3,000
35	Milo	1 sachet	2,500
36	Indomilk	1 sachet	2,000
37	Soy sauce	1 sachet	2,500
38	Sweet soy sauce	1 bottle	12,000
39	Chili Sauce	1 bottle	9,000
40	Instant noodles	1 pack	3,000
41	Toothpaste	1 tube (75 g)	7,000
42	Toothbrush	1 seed	3,500
43	Wrapping Paper	1 pack (8 pieces)	1,500
44	Crackers	1 pack	2,000
45	Zebra Mosquito Repellent	1 seed	1,500
46	Autan	1 sachet	1,000
47	Match	1 sachet	2,000
48	Surya Cigarettes	1 pack	27,000
49	Dji Sam Soe Cigarettes	1 pack	18,000
50	LA Lights Cigarettes	1 pack	32,000
51	Sampoerna Cigarettes	1 pack	28,000
52	Class Mild Cigarettes	1 pack	27,000
53	Black Magnum Cigarettes	1 pack	17,500

No	Product name	Unit	Price (IDR)
54	Blue Magnum Cigarettes	1 pack	22,500
55	Mozza Cigarettes	1 pack	11,000
56	Roll of Tissue	1 roll	5,000
57	Hansaplast	1 seed	1,000
58	betadine	1 bottle	19,000
59	Tissue Box	1 box	8,000
60	Antangin	1 sachet	4,000
61	Repel the Wind	1 sachet	4,000
62	Eucalyptus oil	1 bottle	13,000

Table 1 displays a price list for basic necessities and daily necessities sold in stores. The data covers 62 types of goods, with varying units (kg, liter, sachet, bottle, etc.) and prices per unit in IDR.

b. Operating costs

Type of Fee	Amount
Electricity	500,000
Purchase of Stock of Goods	4,000,000

Table 2 details the shop's monthly operational costs, consisting of electricity payments of IDR 500,000 and stock purchases of IDR 4,000,000 with a total operational cost of IDR 4,500,000/month.

c. Number of Items Sold

Product name	Price per Unit (IDR)	Number of Items Sold per Month	Total Income (IDR)
Rice	15,000	45 kg	675,000
LPG	19,000	20 tubes	380,000
Cooking oil	18,000	41 liters	738,000
Sugar	18,000	39 kg	702,000
Chicken eggs	28,000	35 kg	980,000
Flour	12,500	25 kg	312,500
Robe Flour	2,500	17 sachet	42,500
Tapioca flour	8,000	16 sachet	128,000
Leaf Salt	5,000	29 sachet	145,000
Medium Bottle Aqua	3,000	10 bottles	30,000
Big Bottle Aqua	6,000	5 bottles	30,000
Tea bag	8,000	7 pcs	56,000

Product name	Price per Unit (IDR)	Number of Items Sold per Month	Total Income (IDR)
Red onion	25,000	25 kg	625,000
Garlic	30,000	29 kg	870,000
Red chili pepper	40,000	23 kg	920,000
Cayenne pepper	50,000	17 kg	850,000
Candlenut	30,000	19 kg	570,000
Coriander	40,000	14 kg	560,000
Instant Coconut Milk	3,000	20 sachet	60,000
My Pepper	1,000	21 sachet	21,000
Masako	1,000	27 sachet	27,000
Royco	1,000	19 sachet	19,000
Rinso liquid	2,000	17 sachet	34,000
Soklin	2,000	9 sachet	18,000
Sunlight	2,500	14 sachet	35,000
Molto	2,000	5 sachet	10,000
Giv Soap	3,000	7 sticks	21,000
Dettol Soap	3,000	8 sticks	24,000
Lux Soap	4,000	4 sticks	16,000
Lifebuoy Soap	5,000	7 sticks	35,000
Shampoo	2,000	9 sachet	18,000
Steamer	2,500	20 sachet	50,000
Tora Milk/Mocha	2,500	17 sachet	42,500
Dancow	3,000	6 sachet	18,000
Milo	2,500	4 sachet	10,000
Indomilk	2,000	1 sachet	2,000
Soy sauce	2,500	13 sachet	32,500
Sweet soy sauce	12,000	7 bottles	84,000
Chili Sauce	9,000	3 bottles	27,000
Instant noodles	3,000	19 packs	57,000
Toothpaste	7,000	5 tube	35,000
Toothbrush	3,500	4 seeds	14,000
Wrapping Paper	1,500	130 packs	195,000
Crackers	2,000	8 packs	16,000
Zebra Mosquito Repellent	1,500	5 seeds	7,500
Autan	1,000	10 sachet	10,000
Match	2,000	20 seeds	40,000
Surya Cigarettes	27,000	18 packs	486,000
Dji Sam Soe Cigarettes	18,000	13 packs	234,000
LA Lights Cigarettes	32,000	7 packs	224,000
Sampoerna Cigarettes	28,000	9 packs	252,000
Class Mild Cigarettes	27,000	6 packs	162,000

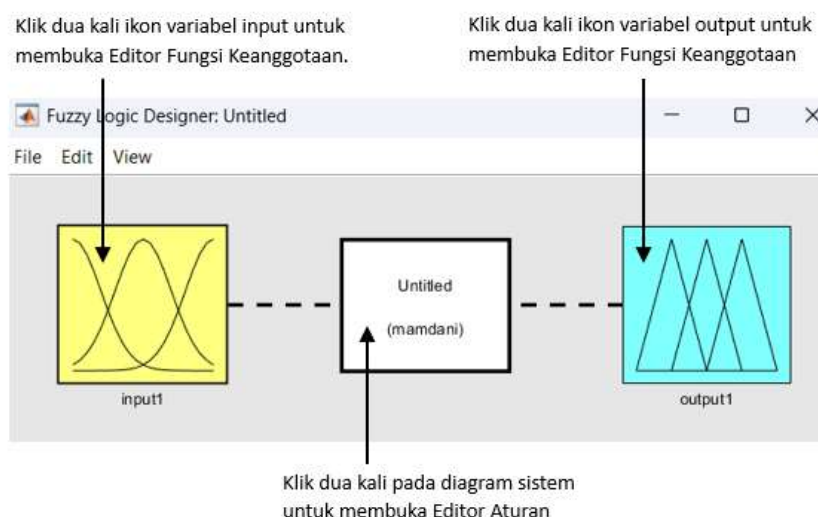
Product name	Price per Unit (IDR)	Number of Items Sold per Month	Total Income (IDR)
Black Magnum Cigarettes	17,500	18 packs	315,000
Blue Magnum Cigarettes	22,500	9 packs	202,500
Mozza Cigarettes	11,000	20 packs	220,000
Roll of Tissue	5,000	5 rolls	25,000
Hansaplast	1,000	3 sachet	3,000
Betadine	19,000	1 bottle	19,000
Tissue Box	8,000	6 boxes	48,000
Antangin	4,000	6 sachet	24,000
Repel the Wind	4,000	5 sachet	20,000
Telon Oil	12,000	2 bottles	24,000
Eucalyptus oil	13,000	3 bottles	39,000

Table 3 shows the sales volume per product in a month, including the total revenue per item. Based on the table, the number of items sold was 1,004 units, and the total price of the items sold was Rp14,124,500 per month.

## B. System Analysis

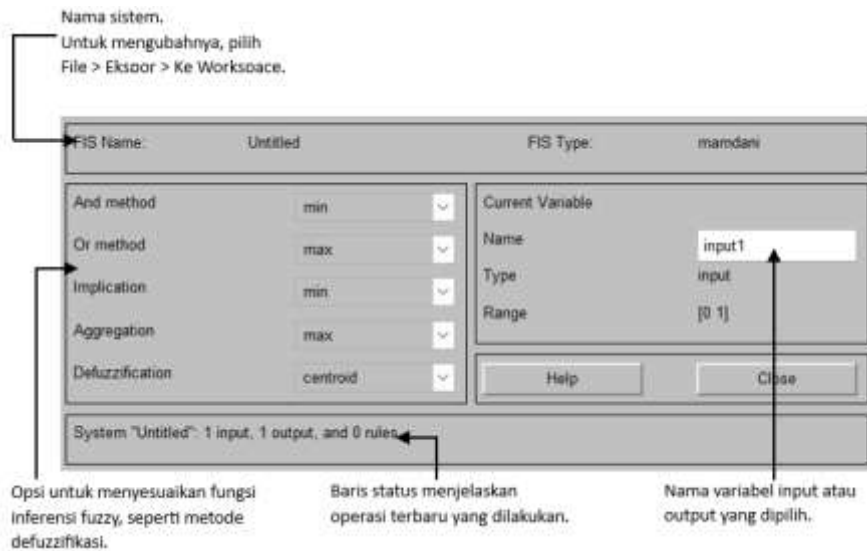
In this study, the software used was Matlab version R2021a. Matlab provides various features and tools for implementing the Mamdani method in fuzzy logic. The steps for using Matlab with the Mamdani method are as follows:

### 1. Fuzzy Logic Designer



**Figure 3** Fuzzy Logic Designer Interface

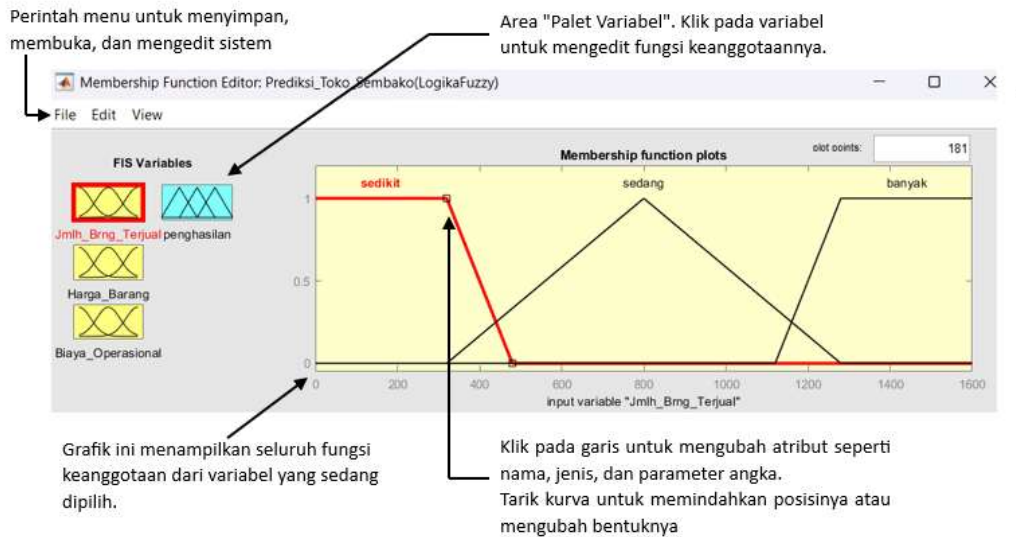
Figure 3 shows the initial view of the Fuzzy Logic Designer in Matlab. This diagram displays the entire fuzzy system flow, from input (left), through the fuzzy inference system (center), to output (right). Users can double-click the input or output icon to open the Membership Function Editor, and click the system diagram to open the Rule Editor. This view represents the initial step in building and managing a fuzzy system based on the Mamdani method.



**Figure 4**( Fuzzy Inference System) Settings Interface

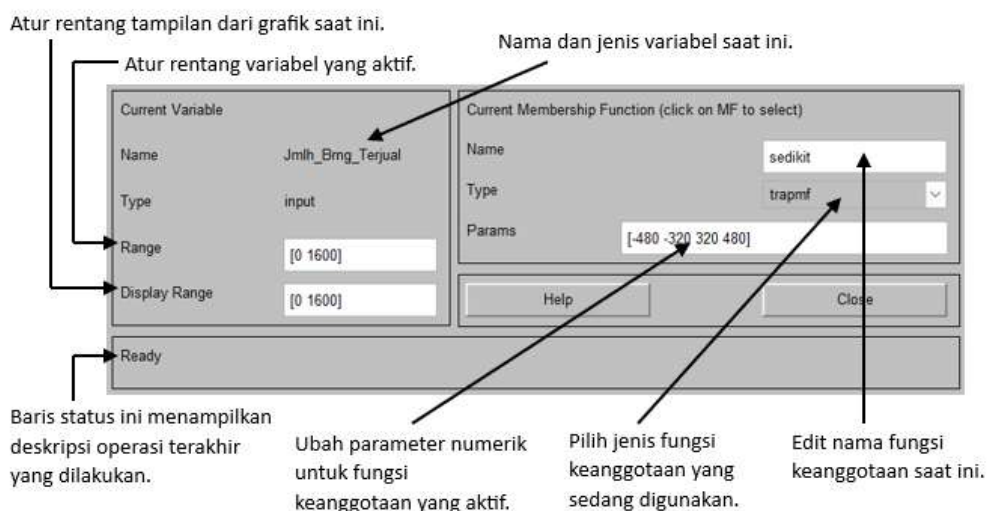
Figure 4 displays the main configuration panel of a fuzzy system in Matlab. On the left are options for customizing fuzzy inference methods, such as the And method, Or method, Implication, Aggregation, and Defuzzification (e.g., the centroid method). On the right, information about the currently active variables is displayed, such as their name, type (input/output), and value range. The status bar at the bottom provides a summary of the system, including the number of inputs, outputs, and rules used. This panel serves as a central point for setting up and identifying components in the fuzzy system being designed.

## 2. Membership Function Editor



**Figure 5**Fuzzy Membership Function Editor

Figure 5 shows the Membership Function Editor interface, which is used to configure the membership function shapes of variables in a fuzzy system. On the left side is the Variable Palette, which displays all input and output variables, such as Qty\_of\_Goods\_Sold, Qty\_of\_Goods, and Qty\_of\_Operational\_Costs. Users can click on any variable to view and edit its membership function graph. The right side displays the membership function graph for the current variable, in this case Qty\_of\_Goods\_Sold, with linguistic categories such as “little,” “medium,” and “many.” Users can click and drag points on the curve to change the shape or range of the function. This interface supports both visual and interactive settings to intuitively refine fuzzy modeling.



**Figure 6**Configuration Panel

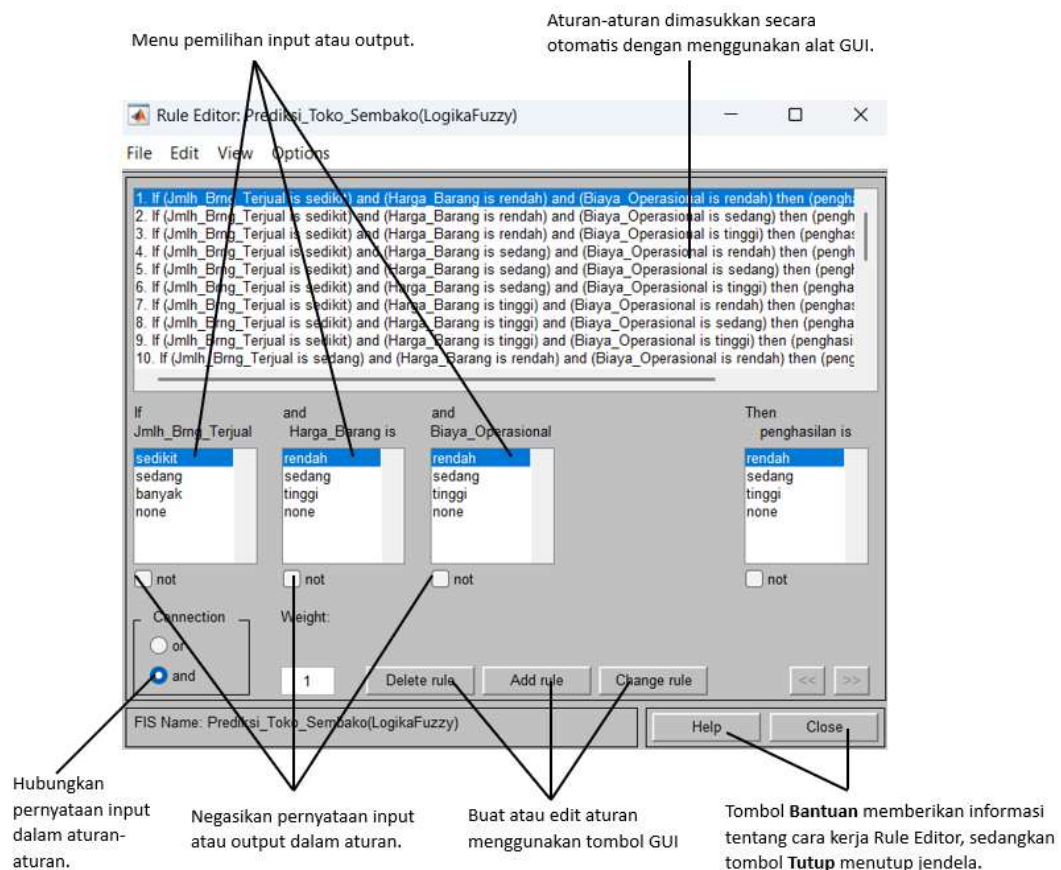
Figure 6 shows the numeric settings panel that appears when the user selects a membership function in the Membership Function Editor. It displays the variable name (Amount\_of\_Sold), its type (input), and its value range.

Users can change:

1. Membership function type (e.g. trapmf or trapezoidal membership function)
2. Numeric parameters that determine the shape of the curve (e.g. [-480 -320 320 480])
3. The name of the currently active membership function (e.g. "few")

The bottom also displays a status bar explaining the last operation performed. This feature is essential for precise setup and accuracy testing of fuzzy systems based on actual data.

### 3. Rules Editor

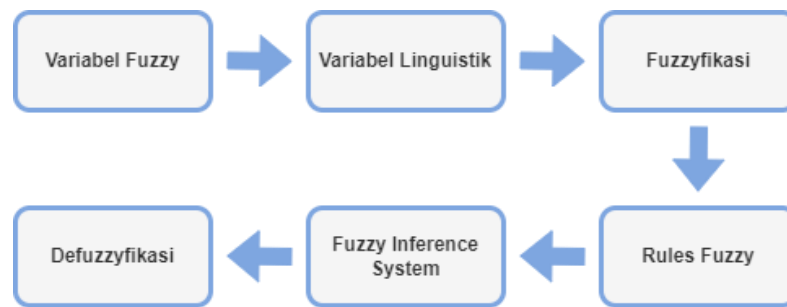


**Figure 7** Editor Interface

Figure 7 shows the Rule Editor in Matlab, which is used to create fuzzy logic rules. Users can select input and output variables, assign linguistic values, and create, edit, or delete rules using the GUI interface.

### C. Data analysis

Data processing with fuzzy logic consists of six stages: determining fuzzy variables, establishing linguistic categories, transforming data into fuzzy form, formulating rules, implementing the inference process, and validating the results [13]. All of these stages are interrelated to produce more accurate decisions, especially in conditions where the data contains uncertainty.



**Figure 8**the Fuzzy Inference System FIS

Based on a month-long observation of a grocery store owner, it was found that 1,004 units of goods were sold, with total sales revenue of Rp14,124,500, and operational expenses reaching Rp4,500,000. So, what is the estimated income?

1. Fuzzy Variables

Variables in a fuzzy system do not represent a single fixed value, but rather have a level of membership in a set that reflects the uncertainty or ambiguity of the data [14]. This study included four variables in a fuzzy function to determine revenue. The input variables were the number of items sold, the price of the items, and operational costs. The output variable was revenue, where the final result indicated the amount earned.

2. Linguistic Variables

Linguistic variables are variables whose values are in the form of linguistic terms (words or phrases) that represent subjective or uncertain concepts, and are usually used in fuzzy logic to model uncertainty and ambiguity in data [15]. In the four fuzzy variables in the study, the determination of linguistic values for each variable was carried out first as follows:

- a. Variable Number of items sold : small, medium, and large.
- b. Price variables for goods : cheap, medium, and many.
- c. Operating cost variables : small, medium, and large.
- d. Income variables : little, medium, and a lot

3. Fuzzyfication Process

The membership function of each variable is determined based on the data obtained, then the fuzzy set is formed using the predetermined membership function. Table 4 explains the grouping of variables used in the fuzzy logic system along with their linguistic categories (fuzzy sets) and numerical intervals. The variables are divided into two main groups: input and output.

**Table 4.** Variables and Fuzzy Sets

Variables	Criteria	Set	Interval
		A little	$\leq 320$
	Number of items sold	Currently	320 - 1280

Variables	Criteria	Set	Interval
Input		Lots	$\geq 1,280$
		Low	$\leq 4,000,000$
	Price of goods	Currently	4,000,000 - 16,000,000
		Tall	$\geq 16,000,000$
		Low	$\leq 2,000,000$
Output	Operating costs	Currently	2,000,000 - 8,000,000
		Tall	$\geq 8,000,000$
	Income	Low	$\leq 4,000,000$
		Currently	4,000,000 - 16,000,000
		Tall	$\geq 16,000,000$

Determine the degree of membership value for each variable as follows:

1) Variable Number of Items Sold (1,004 items)

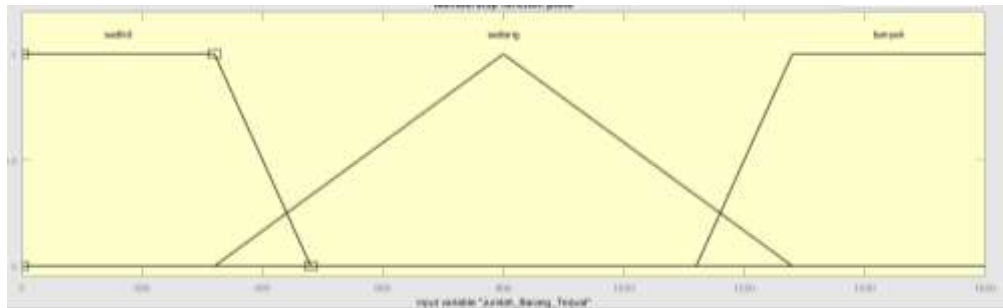


Figure 9 the Variable Number of Items Sold

Figure 9 shows function fuzzy membership for input variable Number of Items Sold in system prediction grocery store income. This function includes three linguistic categories, namely little, medium, and a lot. The membership degree value for the variable number of items sold is as follows:

a. The set of few ( $x$ ).

$$x = \begin{cases} 0; & x \geq 480 \\ \frac{480 - x}{480 - 320}; & 320 \leq x \leq 480 \\ 1; & x \leq 320 \end{cases}$$

1) Since  $x = 1004 \geq 480$ , then  $\mu_{sedikit}(1004) = 0$

b. Medium set ( $x$ )

$$x = \begin{cases} 0; & x \leq 320 \text{ atau } x \geq 1280 \\ \frac{x - 320}{800 - 320}; & 320 \leq x \leq 800 \\ 1; & x = 800 \\ \frac{1280 - x}{1280 - 800}; & 800 \leq x \leq 1280 \end{cases}$$

2) Since  $800 \leq 1004 \leq 1280$ , then:

$$\mu_{sedang}(1004) = \frac{1280 - 1004}{1280 - 800} = \frac{276}{480} = 0.575$$

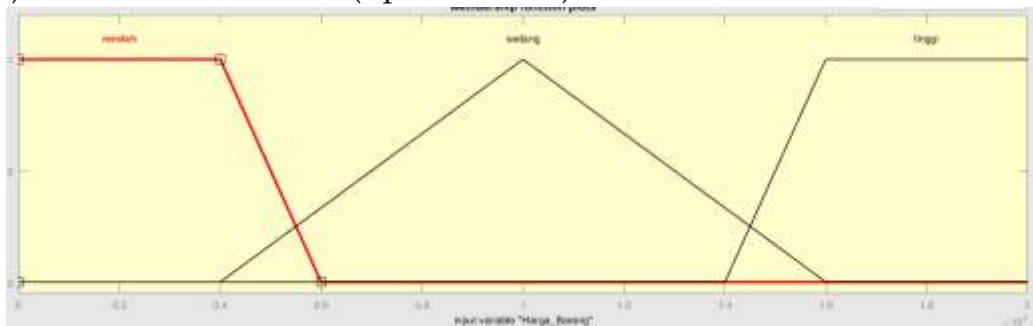
c. The set of many (x)

$$x = \begin{cases} 0; & x \leq 1120 \\ \frac{x - 1120}{1280 - 1120}; & 1120 \leq x \leq 1280 \\ 1; & x \geq 1280 \end{cases}$$

3) Because  $1120 \leq 1004 \leq 1280$  then:

$$\mu_{banyak}(1004) = \frac{1004 - 1120}{1280 - 1120} = \frac{-116}{160} = 0$$

2) Goods Price Variable (Rp. 14,124,500)



**Figure 10** Membership Function Graph of the Price of Goods Variable

Figure 10 display function fuzzy membership for Price of Goods variable in system prediction grocery store income. This function includes three linguistic categories: low, medium, and high. The membership degree values for the item price variable are as follows:

a. Low set (x).

$$x = \begin{cases} 0; & x \geq 6000000 \\ \frac{6000000 - x}{6000000 - 4000000}; & x \leq 4000000, x \geq 6000000 \\ 1; & x \leq 4000000 \end{cases}$$

4) Since  $x = 14124500 \geq 6000000$ , then  $\mu_{rendah}(14124500) = 0$

b. Medium set (x)

$$x = \begin{cases} 0; & x \leq 4000000 \text{ atau } x \geq 16000000 \\ \frac{x - 4000000}{500 - 4000000}; & 4000000 \leq x \leq 10000000 \\ 1; & x = 10000000 \\ \frac{10000000 - x}{16000000 - 10000000}; & 10000000 \leq x \leq 16000000 \end{cases}$$

5) Because  $10000000 \leq 14124500 \leq 16000000$ , then:

$$\mu_{sedang}(14124500) = \frac{16000000 - 14124500}{16000000 - 10000000} = \frac{1875500}{6000000} = 0.3126$$

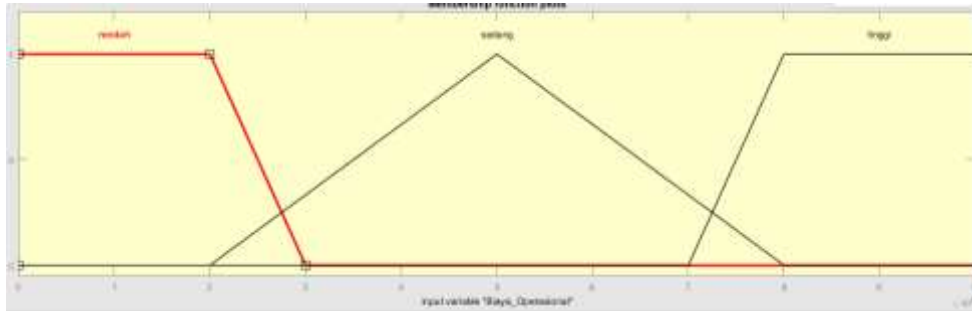
c. Height set (x)

$$x = \begin{cases} 0; & x \leq 14000000 \\ \frac{x - 14000000}{16000000 - 14000000}; & 14000000 \leq x \leq 16000000 \\ 1; & x \geq 16000000 \end{cases}$$

6) Because  $14000000 \leq 14124500 \leq 16000000$  then:

$$\mu_{tinggi}(14124500) = \frac{14124500 - 14000000}{16000000 - 14000000} = \frac{124500}{2000000} = 0.06225$$

3) Operating Cost Variable (Rp. 4,500,000)



**Figure 11** Membership Function Graph of Operational Cost Variable

Figure 11 display function fuzzy membership for variables Operating costs in system prediction grocery store income. This function includes three linguistic categories, namely low, medium, high. The membership degree values for the operational cost variables are as follows:

a. Low set (x).

$$x = \begin{cases} 0 & ; x \geq 3000000 \\ \frac{3000000 - x}{3000000 - 2000000} & ; x \leq 2000000, x \geq 3000000 \\ 1 & ; x \leq 2000000 \end{cases}$$

1) Because  $x = 4500000 \geq 3000000$ , then  $\mu_{rendah}(4500000) = 0$

b. Medium set (x)

$$x = \begin{cases} 0; & x \leq 2000000 \text{ atau } x \geq 8000000 \\ \frac{x - 2000000}{5000000 - 2000000}; & 2000000 \leq x \leq 5000000 \\ 1; & x = 5000000 \\ \frac{5000000 - x}{8000000 - 5000000}; & 5000000 \leq x \leq 8000000 \end{cases}$$

2) Because  $2000000 \leq 4500000 \leq 5000000$ , then:

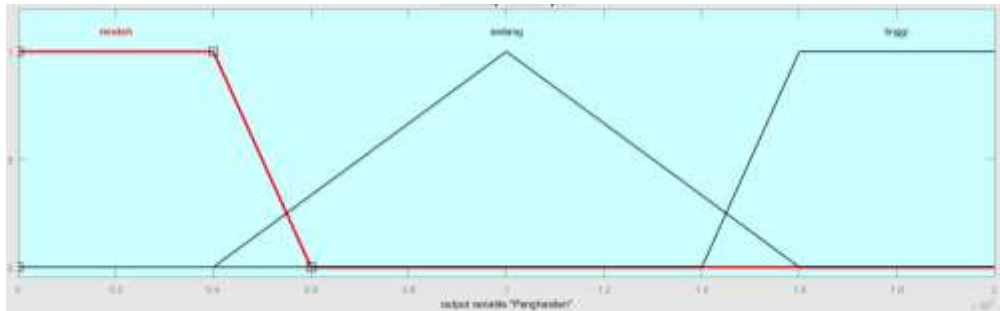
$$\mu_{sedang}(4500000) = \frac{4500000 - 2000000}{5000000 - 2000000} = \frac{2500000}{3000000} = 0.8333$$

c. Height set (x)

$$x = \begin{cases} 0 & ; x \leq 7000000 \\ \frac{x - 7000000}{8000000 - 7000000} & ; 7000000 \leq x \leq 8000000 \\ 1 & ; x \geq 8000000 \end{cases}$$

3) Because  $4500000 \leq 7000000$ , then  $\mu_{tinggi}(4500000) = 0$

4) Income Variable



**Figure 12** Membership Function Graph of Income Variable

Figure 12 display function fuzzy membership for variables Income in system prediction grocery store income. This function includes three linguistic categories, namely low, medium, high. The membership degree values for the income variable are as follows:

a. Low set (x).

$$x = \begin{cases} 0; x \geq 6000000 \\ \frac{6000000 - x}{6000000 - 4000000}; x \leq 4000000, x \geq 6000000 \\ 1; x \leq 4000000 \end{cases}$$

b. Medium set (x)

$$x = \begin{cases} 0; x \leq 4000000 \text{ atau } x \geq 16000000 \\ \frac{x - 4000000}{500 - 4000000}; 4000000 \leq x \leq 10000000 \\ 1; x = 10000000 \\ \frac{10000000 - x}{16000000 - 10000000}; 10000000 \leq x \leq 16000000 \end{cases}$$

c. Height set (x)

$$x = \begin{cases} 0; x \leq 14000000 \\ \frac{x - 14000000}{16000000 - 14000000}; 14000000 \leq x \leq 16000000 \\ 1; x \geq 16000000 \end{cases}$$

#### 4. Fuzzy Rules

The following are the rules that have been made:

1. If the number of products sold is small, the product price is cheap, and the operational costs are low, then the income is low.
2. If the number of products sold is small, the product price is cheap, and the operational costs are moderate, then the income is low.

3. If the number of products sold is small, the product price is low, and operational costs are high, then the income is low.
4. If the number of products sold is small, the product price is moderate, and operational costs are low, then the income is low.
5. If the number of products sold is small, the product price is moderate, and the operational costs are moderate, then the income is low.
6. If the number of products sold is small, the product price is moderate, and operational costs are high, then the income is low.
7. If the number of products sold is small, the product price is high, and operational costs are low, then the income is moderate.
8. If the number of products sold is small, the product price is high, and the operational costs are moderate, then the income is moderate.
9. If the number of products sold is small, the product price is high, and the operational costs are high, then the income is moderate.
10. If the number of products sold is moderate, the product price is cheap, and the operational costs are low, then the income is low.
11. If the number of products sold is moderate, the product price is low, and the operational costs are moderate, then the income is low.
12. If the number of products sold is moderate, the product price is low, and operational costs are high, then the income is moderate.
13. If the number of products sold is moderate, the product price is moderate, and the operational costs are low, then the income is low.
14. If the number of products sold is moderate, the product price is moderate, and the operational costs are moderate, then the income is moderate.
15. If the number of products sold is moderate, the product price is moderate, and operational costs are high, then the income is moderate.
16. If the number of products sold is moderate, the product price is high, and the operational costs are low, then the income is moderate.
17. If the number of products sold is moderate, the product price is high, and the operational costs are moderate, then the income is moderate.
18. If the number of products sold is moderate, the product price is high, and the operational costs are high, then the income is high.
19. If the number of products sold is large, the product price is cheap, and operational costs are low, then the income is moderate.
20. If the number of products sold is large, the product price is cheap, and the operational costs are moderate, then the income is moderate.
21. If the number of products sold is large, the product price is low, and operational costs are high, then the income is moderate.
22. If the number of products sold is large, the product price is moderate, and operational costs are low, then the income is moderate.
23. If the number of products sold is large, the product price is moderate, and the operational costs are moderate, then the income is moderate.

24. If the number of products sold is large, the product price is moderate, and operational costs are high, then the income is high.
25. If the number of products sold is large, the product price is high, and operational costs are low, then the income is high.
26. If the number of products sold is large, the product price is high, and the operational costs are moderate, then the income is high.
27. If the number of products sold is large, the product price is high, and the operational costs are high, then the income is high.

#### 5. Fuzzy Inference

Based on the given fuzzy rules, then evaluate the rules relevant to the input:

- a. Number of Items Sold : Medium (0.575), Lots (0)
- b. Item Price : Medium (0.3126), High (0.06225)
- c. Operating Costs : Medium (0.8333), High (0)

Relevant rules:

- 1) Rule 14: If the Number of Items Sold is Moderate, the Price of the Item is Moderate, the Operating Costs are Moderate, then the Income is Moderate.
  - a. Degree of membership :  $\min(0.575, 0.3126, 0.8333) = 0.3126$
  - b. Output : Medium (4,000,000 – 16,000,000)
- 2) Rule 15: If the Number of Items Sold is Moderate, the Price of the Item is Moderate, the Operating Costs are High, then the Income is Moderate.
  - a. Degree of membership :  $\min(0.575, 0.3126, 0) = 0$
  - b. Output : irrelevant
- 3) Rule 17: If the Number of Items Sold is Medium, the Price of the Items is High, the Operating Costs are Medium, then the Income is Medium.
  - a. Degree of membership :  $\min(0.575, 0.06225, 0.8333) = 0.06225$
  - b. Medium Output : (4,000,000 – 16,000,000)
- 4) Rule 18: If the Number of Items Sold is Medium, the Price of the Items is High, the Operating Costs are High, then the Income is High.
  - a. Degree of membership :  $\min(0.575, 0.3126, 0) = 0$
  - b. Output : irrelevant

#### 6. Defuzzification

Using the Weighted Average method:

- a. Rule 14:  $a_1 = 0.3126, z_1 = 10,000,000 = 10,000,000$  (midpoint Medium).
- b. Rule 17:  $a_2 = 0.06225, z_2 = 10,000,000 = 10,000,000$  (midpoint Medium).

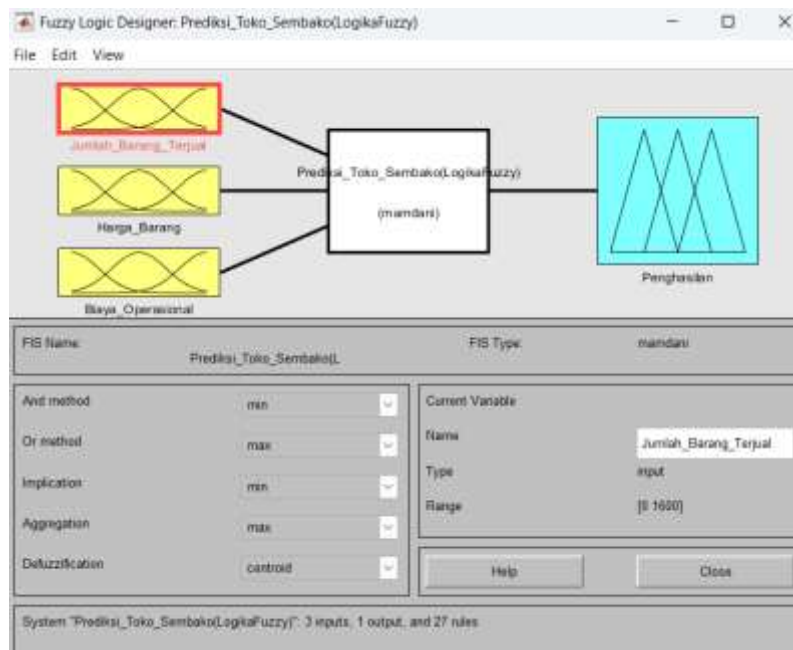
$$\begin{aligned}
 WA &= \frac{a_1 * z_1 + a_2 * z_2 + \dots + a_n * z_n}{a_1 + a_2 + \dots + a_n} \\
 &= \frac{0,3126 * 10,000,000 + 0,06225 * 10,000,000}{0,3126 + 0,06225} \\
 &= \frac{3,126,000 + 622,500}{0,37485} \\
 &= \frac{3,748,500}{0,37485}
 \end{aligned}$$

$$= 10,000,000$$

The income generated is 10,000,000

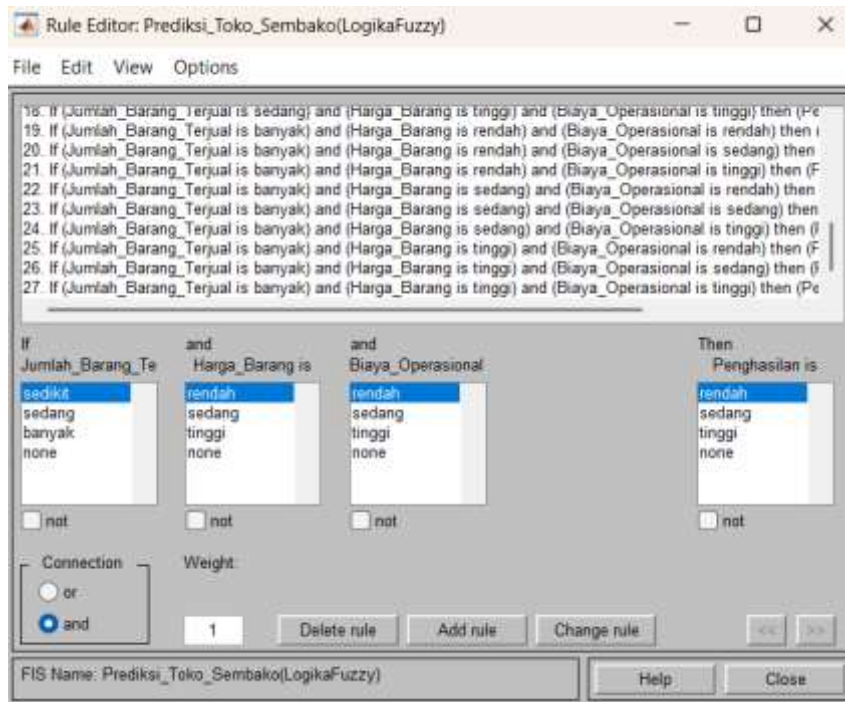
#### D. Fuzzy Logic Income Prediction Using Matlab

Figure 13 display Fuzzy Logic Designer interface for Grocery Store Prediction System (Fuzzy Logic) for predict grocery store income based on three input variables, namely amount goods sold, price goods and costs operational.



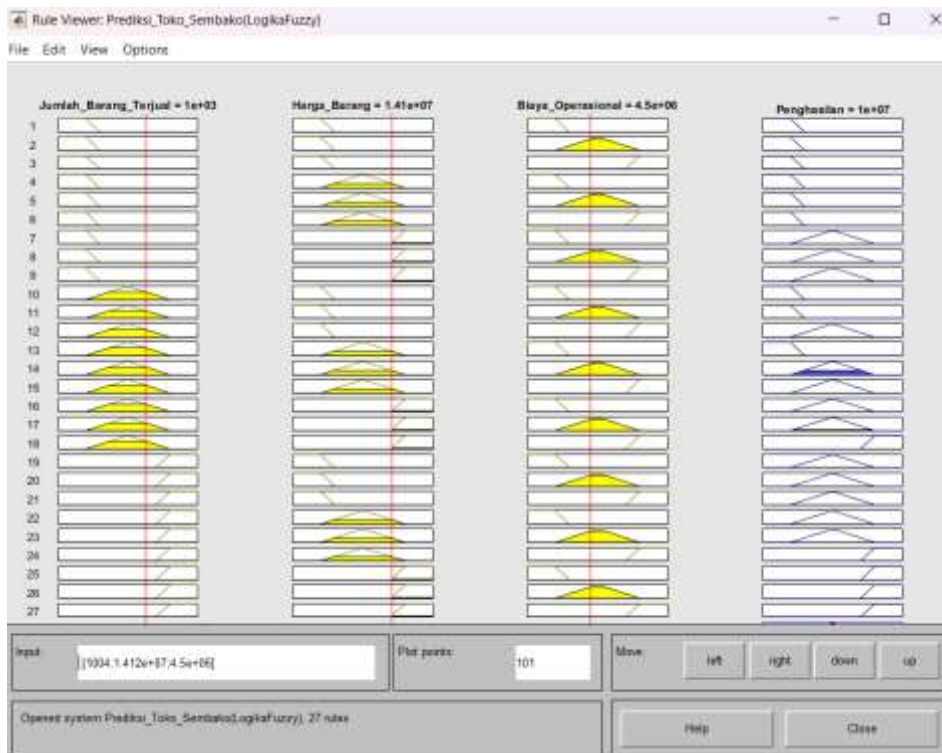
**Figure 13** Fuzzy Designer Interface for Grocery Store Prediction

In Figure 14 there are 27 rules that have been provided made previously rule This connecting 3 input variables with 1 output variable.



**Figure 14**Fuzzy Rules Editor for Grocery Store

System This will arrange fuzzy rules based on input data at the grocery store that will predicted his income. It is known amount goods sold there are 1004 items, total quantity price goods sold is Rp 14,124,500 and Operational Costs are Rp 4,500,000. Based on the input variable data, how much income is generated?



**Figure 15**Fuzzy Simulation Results of Grocery Store

The explanation in figure 15 is as following :

1. Input :
  - a. Amount goods sold : 1,004 categories moderate-large
  - b. Price of goods : 14,124,500 high category
  - c. Operational costs : 4,500,000 medium-low category
2. Output :
  - a. Income : 10,000,000 category medium-high

So, the prediction income from grocery stores amounting to Rp. 10,000,000

For calculate the average percentage error absolute between mark actual and value prediction, then using formula MAPE (Mean Absolute Percentage Error).

$$MAPE = \frac{\text{nilai aktual} - \text{nilai prediksi}}{\text{nilai aktual}} * 100\%$$

$$MAPE = \frac{10,000,000 - 10,000,000}{10,000,000} * 100\%$$

$$MAPE = 0\%$$

Based on results the above calculation, the Weighted Average method was analyzed using MAPE produces error value of 0%, which indicates level accuracy or success by 100%.

## CONCLUSION

**Fundamental Finding :** This study demonstrates that the Mamdani fuzzy logic method can be effectively applied to predict grocery store revenue with high accuracy, using three key input variables – quantity of goods sold, price of goods, and operational costs – to represent the complexity and uncertainty inherent in retail operations. The implementation using Matlab R2021a produced a predicted revenue of Rp10,000,000 with 100% accuracy based on MAPE analysis, validating the model's precision. **Implication :** These results highlight the potential of fuzzy logic as a reliable decision-support tool for financial forecasting, enabling micro and small businesses to enhance planning accuracy and respond proactively to market fluctuations. **Limitation :** However, the model's testing was limited to a controlled dataset, and the absence of real-time or large-scale data may restrict the generalizability of the outcomes. **Future Research :** Subsequent studies should incorporate broader datasets, include real-time data integration, and explore hybrid approaches combining fuzzy logic with machine learning to improve adaptability and predictive performance in diverse retail contexts.

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