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Application of Fuzzy Logic Mamdani Method to Determine the Amount of Ayudes Production (Case Study: CV. Abadi Tiga Mandiri Ambon)

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ABSTRACT

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A company is inseparable from a problem, namely the level of competition. This competition forces companies to adjust their marketing strategies or productivity in order to survive and even have to increase the amount of production. If the amount of production is less than the demand, the company will not be maximized to get maximum profit and vice versa. Therefore, what needs to be considered in determining the amount of production is the amount of demand and supply. The writing and discussion in this study are about applying the Mamdani Method Fuzzy Logic (Min-Max) to determine the amount of production based on the amount of demand and supply where data is taken from CV. Abadi Tiga Mandiri Ambon. By applying the Mamdani fuzzy logic method and Matlab assistance, a level of truth reaching 93.238% is obtained. Therefore, applying the Mamdani Method of Fuzzy Logic can help companies determine the number of goods that must be produced.

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1. Introduction

Companies specifically engaged in the industry cannot be separated from the problem of competitive competition. This competition forces companies to be able to adjust their marketing strategies or productivity so that they survive and even have to increase the amount of production [1], [2]. Production is an action that aims to produce an item, both labor and products, which are then used by buyers [1]-[5]. Production is utilizing open resources to get the best results expected. Meanwhile, in terms of economic understanding, production is utilizing all available resources to obtain results guaranteed in quality and quantity and well managed so that it is a commodity that can be traded [2]-[5], [9]-[11].

Fuzzy logic was first proposed by Prof. Lothfi A. Zadeh, an Iranian American researcher from the College of California at Berkeley, through writing in 1965 [6], [7]. Fuzzy logic is one of the powerful mathematical methods for representing uncertainty in all fields [8]-[15]. As the basic concept of fuzzy systems, fuzzy logic calculates an input variable based on its fuzzy value [7]. Fuzzy in fuzzy set theory, expressed in degrees of membership and degrees of truth, simultaneously states partly true and partly false.

Fuzzy methods are very easy to understand because the process uses etymological strategies and has fuzzy algorithms that can be dissected numerically [12]-[16]. The Mamdani method is often referred to as the Min-Max method. Mamdani fuzzy logic is one fully customizable method that can bear existing information [7]. Thinking using the Mamdani method is practically the same as the Sugeno method, except that the output (consequent) is certainly not a constant or linear equation but a fuzzy set [9]-[10], [13]-[14]. In determining the amount of Ayude production, the Mamdani method, often called the Min-Max method, was used. In this method, each rule in the form of implication (cause-effect) antecedent in the form of conjunction (AND) has a min (minimum) urban value, while the combined consequent is max (maximum).

The main objective of this research was to determine the optimal number of mineral water production (Ayudes) at CV. Abadi Tiga Mandiri (Ayudes) using the Mamdani fuzzy method (MIN-MAX).

2. Research Methods

The type of research in this study is a case study, which took data at CV Abadi Tiga Mandiri (AYUDES) in the form of demand data and Ayudes supply data. It was used to determine the amount of Ayudes production. Two types of variables are used in this research, namely input variables and output variables. The input variables consist of supply data and the number of requests, each with three *fuzzy* sets (few, medium, and many). Then, the output variable is the amount of production, which also has three *fuzzy* sets (few, medium, and many). This study used secondary data. The data was in the form of the amount of supply and the amount of public demand in January 2020 - December 2020 at CV. Abadi Tiga Mandiri (AYUDES).

The stages undertaken to answer the exploratory objectives in this review are:

1. Data collection
   a. Data on demand amount
   b. Data on supply amount
   c. Data on production amount
2. Data processing
   a. Define variables and scope of discussion
   b. Determining the membership function (*fuzzification*)
   c. Define *fuzzy* rules
   d. *Inference*
   e. *Defuzzification*
3. Results and Conclusion

3. Results and Discussion

3.1. Data of Research Result

The data collected in this study include demand data, supply data, and data on production in 2020. The data starts from January 2020-December 2020. These data are data with cardboard units and can be seen in **Table 1** below:

Table 1. Demand, Supply, and Production Data

Month	Inquiry	Supplies	Production
January 2020	149.420	5987	158.565
February 2020	126.556	7603	152.950
April 2020	118.650	8745	132.870
May 2020	184.481	6023	174.933
June 2020	165.780	5816	155.760
July 2020	137.795	7195	158.317
August 2020	147.250	8318	155.062
September 2020	162.900	8145	161.739
October 2020	148.800	9209	168.733
November 2020	194.640	9772	206.580
December 2020	222.270	9164	213.360

3.2. Data Processing Using the Mamdani Fuzzy Method

In determining the amount of Ayudes production from January 2020 to December 2020, the processing used the *fuzzy* Mamdani (Min-Max) method. There were five stages in the Mamdani *fuzzy* method in obtaining *output*: determining the *fuzzy* set, *fuzzification*, *fuzzy* rule formation, *inference*, and *defuzzification*. The following are the stages:

3.2.1 Creating a *Fuzzy* Set

The *fuzzy* Mamdani method divides input and output variables into one or more *fuzzy* sets. In this study, the variables were divided into two parts, namely input variables and output variables. Input variables were divided into two, namely demand variables and supply variables, while there is one output variable, namely the variable amount of production. For each variable, there are three *fuzzy sets*, namely few, medium, and many *fuzzy sets*. Meanwhile, the domain for the composition of *fuzzy* rules is demand data with the smallest and largest values, supply data with the smallest and largest values, and data on the amount of production with the smallest value and the largest value in one year obtained from the company. Then, the scope of discussions is the values that are the *range* used to give limits to this research data. The determination of the variables used in this study is shown in **Table 2**.

Table 2. *Fuzzy* variables

Function	Name / Variables	*Fuzzy* Set Name	Talking Universe	Domain
Input	Demand	Few	[113.000-223.000]	[113.274-167.772]
		Medium		[113.274-222.270]
		Many		[167.772-222.270]
	supply	Few	[5800-9800]	[5816-7794]
		Medium		[5816-9772]
		Many		[7794-9772]
Output	Production	Few	[100.000-250.000]	[100.096-170.048]
		Medium		[100.096-240.000]
		Many		[170.048-240.000]

3.2.2 Performing *fuzzification*

- Membership functions of FEW, MEDIUM, and MANY *Fuzzy* sets of Demand variables

$$\mu[x]FEW = \begin{cases} 1 & ; x \le 113.274 \\ 1 - 2\left[\dfrac{x-\alpha}{\gamma - a}\right]^2 & ; 113.274 \le x \le 140.523 \\ 2\left[\dfrac{\gamma - x}{\gamma - a}\right]^2 & ; 140.523 \le x \le 167.772 \\ 0 & ; x \ge 167.772 \end{cases}$$

$$\mu[x]MEDIUM = \begin{cases} S(x: 113.274;\ 140.523;\ 167.772) & ; x \le 167.772 \\ 1 - S(x: 167.772;\ 195.021;\ 140.523;\ 222.270) & ; x > 167.772 \end{cases}$$

$$\mu[x]MANY = \begin{cases} 0 & ;\ x \leq 167.772 \\ 2\left[\dfrac{x-\alpha}{\gamma-\alpha}\right]^2 & ; 167.772 \leq x \leq 195.021 \\ 1-2\left[\dfrac{\gamma-x}{\gamma-a}\right]^2 & ; 195.021 \leq x \leq 222.270 \\ 1 & ; x \geq 222.270 \end{cases}$$

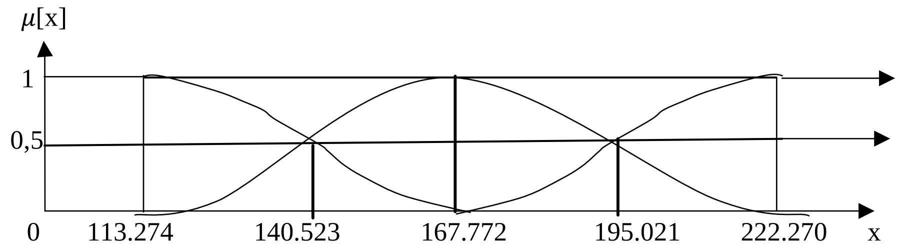

Figure 1. *Fuzzy* Set of Demand Variables

- Membership functions of the FEW, MEDIUM, and MANY Fuzzy sets of the supply variable.

$$\mu[y]FEW = \begin{cases} 1 & ; y \leq 5.816 \\ 1-2\left[\dfrac{y-\alpha}{\gamma-a}\right]^2 & ; 5.816 \leq y \leq 6.805 \\ 2\left[\dfrac{\gamma-y}{\gamma-a}\right]^2 & ; 6.805 \leq y \leq 7.794 \\ 0 & ; y \geq 7.794 \end{cases}$$

$$\mu[y]MEDIUM = \begin{cases} S(y: 5.816;\ 6.805;\ 7.794) & ; x \leq 7.794 \\ 1 - S(y: 7.794;\ \ 8.783;\ \ 6.805;\ \ 9.772) & ; x > 7.794 \end{cases}$$

$$\mu[y]MANY = \begin{cases} 0 & ;\ y \leq 7.794 \\ 2\left[\dfrac{y-\alpha}{\gamma-\alpha}\right]^2 & ; 7.794 \leq y \leq 8.783 \\ 1-2\left[\dfrac{\gamma-y}{\gamma-a}\right]^2 & ; 8.783 \leq y \leq 9.772 \\ 1 & ; y \geq 9.772 \end{cases}$$

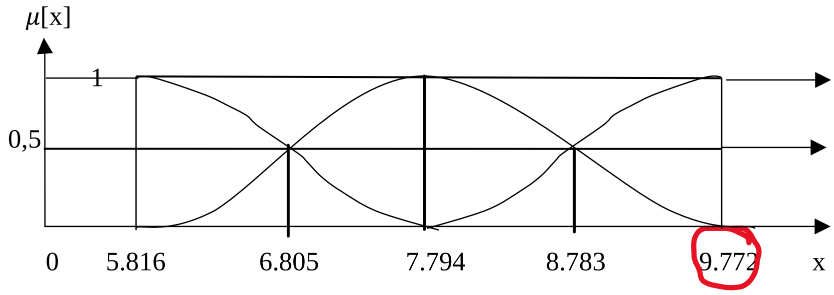

Figure 2. *Fuzzy* Set of Supply Variables

- The membership functions of the FEW, MEDIUM, and MANY Fuzzy sets of the Production variable.

$$\mu[z]FEW = \begin{cases} 1 & ; z \leq 100.096 \\ 1-2\left[\dfrac{y-\alpha}{\gamma-a}\right]^2 & ; 100.096 \leq z \leq 135.072 \\ 2\left[\dfrac{\gamma-y}{\gamma-a}\right]^2 & ; 135.072 \leq z \leq 170.048 \\ 0 & ; z \geq 170.048 \end{cases}$$

$$\mu[x]MEDIUM = \begin{cases} S(z: 5.816;\ 6.805;\ 7.794) & ; z \leq 170.048 \\ 1 - S(z: 7.794;\ \ 8.783;\ \ 6.805;\ \ 9.772) & ; z > 170.048 \end{cases}$$

$$\mu[z]MANY = \begin{cases} 0 & ; z \leq 170.048 \\ 2\left[\frac{y-\alpha}{\gamma-\alpha}\right]^2 & ; 170.048 \leq z \leq 205.024 \\ 1 - 2\left[\frac{\gamma-y}{\gamma-a}\right]^2 & ; 205.024 \leq z \leq 240.000 \\ 1 & ; z \geq 240.000 \end{cases}$$

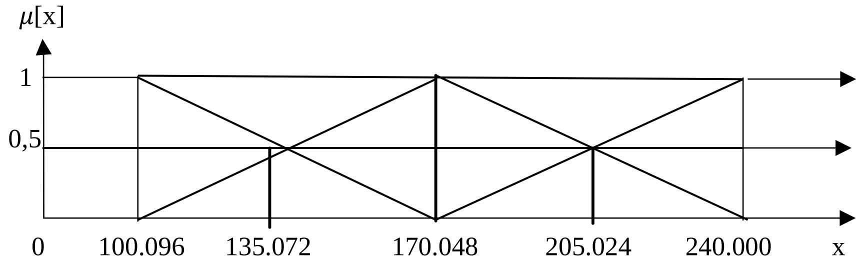

Figure 3. *Fuzzy* set of production variables

3.2.3 Fuzzy Rule Formation

In this section, the membership values of the demand and supply sets were sought using the Fuzzy set membership function. The formation of fuzzy rules was from two input variables and one output variable that has been defined. It was done by analyzing the data on the boundaries of each fuzzy set for each variable. Nine fuzzy rules were used in this system, with the arrangement of the rules IF demand IS... AND supply IS... THEN production IS...., the results can be seen in **Table 3**:

Table 3. *Fuzzy* Rules

No.	Variables		
	Input		Output
	Demand	Supply	Production
1	Few	Few	Few
2	Few	Medium	Few
3	Few	Many	Few
4	Medium	Few	Medium
5	Medium	Medium	Medium
6	Medium	Many	Medium
7	Many	Few	Many
8	Many	Medium	Many
9	Many	Many	Many

3.2.4 Application of Implication function

This stage was to determine α- predicate of each rule by using the *min* implication function, which takes the smallest value from both sets of rules.

3.2.5 Rule Composition

The Max function is the composition of the rules used. Therefore, the fuzzy set solution is obtained by taking the maximum value of the rule, then using it to modify the fuzzy region. The overall conclusion was taken from the maximum membership level of each consequent of the implication function application by combining each rule's conclusions as a rule composition.

3.2.6 Defuzzification

The last stage of the Mamdani Fuzzy Method system is the defuzzification cycle. The defuzzification value was calculated using the centroid method. The defuzzification interaction decomposes fuzzy membership into certain decisions or natural numbers [6]. The defuzzification stage using the equation below and the results obtained as shown in **Table 4.**

$$Z = \frac{\int_a^b Z.\mu_{(Z)}.dz}{\int_a^b \mu_{(Z)}.dz}$$

Table 4. Number of Products to be Produced Based on Demand and Supply Input (*Fuzzy* Mamdani)

Month	Demand	Supply	Production	*Fuzzy* Productions
January 2020	149.420	5987	158.565	168.338
February 2020	126.556	7603	152.950	138.716
March 2020	113.274	6355	100.096	123.866
April 2020	118.650	8745	132.870	130.389
May 2020	184.481	6023	174.933	171.230
June 2020	165.780	5816	155.760	170.048
July 2020	137.795	7195	158.317	157.985
August 2020	147.250	8318	155.062	167.387
September 2020	162.900	8145	161.739	170.037
October 2020	148.800	9209	168.733	168.107
November 2020	194.640	9772	206.580	177.900
December 2020	222.270	9164	213.360	215.986

From the results of the application of Mamdani *fuzzy* logic, the results of the comparison of Mamdani *fuzzy* logic assessment with the production of CV. Using the average percentage or *Mean Percentage Error* (MPE), Abadi Tiga Mandiri Ambon can be seen in **Table 5**. In calculating with MPE, the company's production data were assumed as α_t, while $\tilde{\alpha}_t$ is Mamdani *fuzzy* production data, and n is the data used.

Table 5. MPE calculation

Month	α_t Production	$\tilde{\alpha}_t$ Fuzzy	Error	$\left\lvert \frac{(\alpha_t - \tilde{\alpha}_t)}{\alpha_t} \times 100\% \right\rvert$
January 2020	158.565	168.338	9.773	6,1634
February 2020	152.950	138.716	14.234	9,30631
March 2020	100.096	123.866	23.770	23,7472
April 2020	132.870	130.389	2.481	1,86724
May 2020	174.933	171.230	3.703	2,11681
June 2020	155.760	170.048	14.288	9,17309
July 2020	158.317	157.985	332	0,20971
August 2020	155.062	167.387	12.325	7,94843
September 2020	161.739	170.037	8.298	5,13049
October 2020	168.733	168.107	626	0,371
November 2020	206.580	177.900	28.680	13,88324
December 2020	213.360	215.986	2.626	1,23078

Then,

$$MPE = \frac{\sum_{t=1}^{n} \frac{\alpha_t - \tilde{\alpha}_t}{\alpha_t} \times 100\%}{n}$$
$$= \frac{81{,}1477\%}{12}$$
$$= 6{,}762\%$$
$$100\% - 6{,}762\% = 93{,}238\%$$

Therefore, the calculation of the average percentage error of the *fuzzy* logic Mamdani method is 6.762%, while the correctness rate of the Mamdani *fuzzy* logic calculation results is 93.238%. Therefore, the calculation results of the *fuzzy* logic Mamdani method used in this system can determine the amount of Ayudes production at CV. Abadi Tiga Mandiri Ambon.

3.3 Data Processing with Matlab Toolbox R2009

To find out the description of each ayudes demand, supply, and production amount, testing was carried out using *Matlab Toolbox R2009*. This testing method was done by contributing to the input column in the *rule viewer*. The contribution given later affects the results. By using January 2020 data with a demand of 149,420 cartons and a supply of 5,987, the results obtained are shown in **Figure 4** as follows:

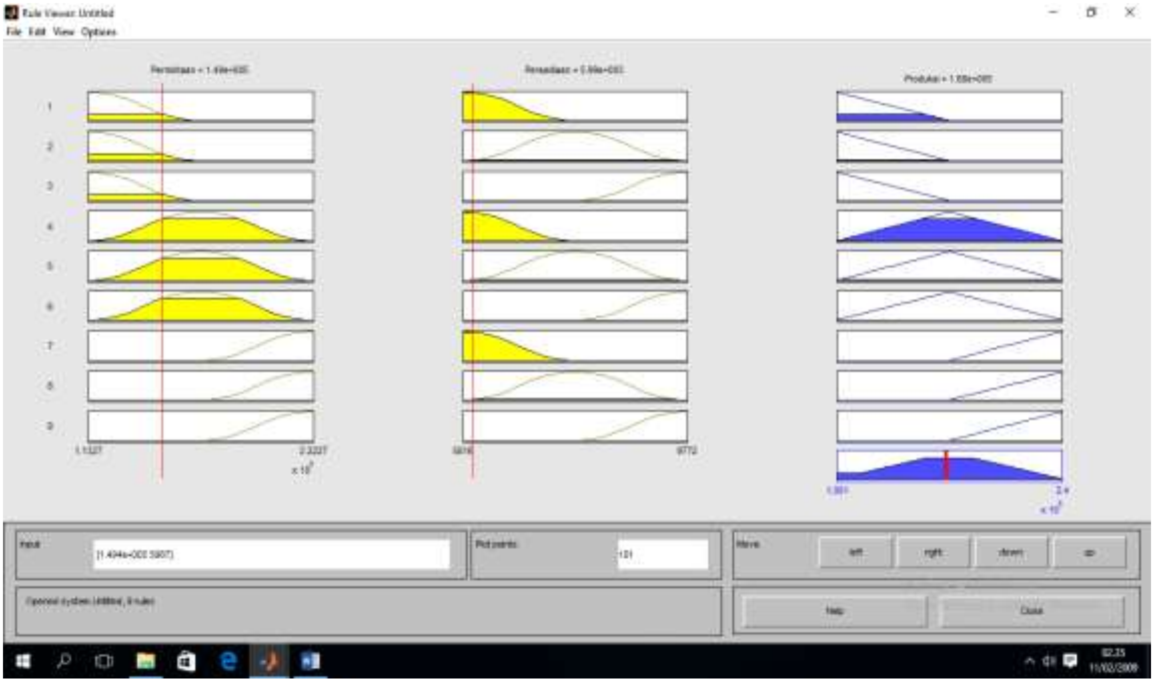

Figure 4. Testing Results

4. Conclusions

To determine the amount of production from January 2020 to December 2020, data processing was carried out using the *Min-Max* (Mamdani) method, where the affirmation or *defuzzification* using the *centroid* method was obtained for January by entering the input variables, namely the number of requests of 149,420 cartons and the amount of supply of 5,987 cartons. The results obtained for the amount of production in January 2020 are 168,338 cartons. By doing the same way, the results obtained are listed in **Table 5.**

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