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**Submission date:** 30-Nov-2023 05:57PM (UTC-0500)
**Submission ID:** 2236631964
**File name:** 7051-18962-1-SM.docx (581.65K)
**Word count:** 1984
**Character count:** 10240

JIKO (Jurnal Informatika dan Komputer)
Vol. x, No. x, April 2023, hlm. x-x
DOI: 10.33387/jiko

Accredited KEMENDIKBUD RISTEK, No.105/E/KPT/2022
p-ISSN: 2614-8897
e-ISSN: 2656-1948

# COMPARISON OF SUGENO AND MAMDANI FUZZY SYSTEM PERFORMANCE IN PREDICTING THE AMOUNT OF VIRGIN COCONUT OIL (VCO) PRODUCTION

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(Received: dd mmm yyyy, Revised: dd mmm yyyy, Accepted: dd mmm yyyy)

**Abstract**

In the future, a tight industrial competition.The professional manage companies become crucial to successful so competitive on the global market.One of the key figure in production is the ability to plan and optimize goods production process. To face fluctuations of consumer demand without adding existing facilities, The company can use fuzzy mammal and sugeno methods to determine the amount of production of voc (virgin organic coconut) based on supply and demand data in the wotay coconut (main business area). process involving 18 fuzzy rules using AND and OR operators on each fuzzy set and IF-THEN rules for each input variable demand (little, medium, a lot), inventory (little, medium, a lot), output (little, medium , Lots). The thing that strengthens the conclusion that fuzzy sugeno is better than fuzzy mamdani with this data is that the MAPE for fuzzy sugeno has a value of 36.11% with a truth level of 63.89%, while for fuzzy mamdani the MAPE value is 38.77%, with a truth level 61.23 %. With the MAPE value obtained from Fuzzy Mamdani and Sugeno, the forecast for VOC production at KBU is predicted. Wootay Coconut is worth using with fuzzy sugeno.

**Keywords**: *Fuzzy Mamdani, Fuzzy Sugeno, Production,Demand, Supply*



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## 1. INTRODUCTION

In the present era of globalization., Industrial competition has become very strict.Professional ability to manage companies is crucial to success in a global market that is so competitive.One of the key aspects of production is the ability to plan and optimize the production process..

Get the maximum profit depending on the maximum sales.Maximum sales means to meet all existing demands.If the company produces less than demand, Opportunities for optimal profit will be missed.On the contrary, If the production exceeds demand, The company will face losses. then production planning within a company is essential to correctly respond to market demand.Factors such as supply and demand are key to optimize production.

By applying the method in mamdani fuzzy logic, companies to make decisions more precision production, consider the inventories and the market.This approach enabled firms to maximize shareholder profit by producing optimal amount of goods in accordance with the market[1].

In dealing with the fluctuation of consumer demand without adding to the facility, The company can use fuzzy mammani and sugeno methods to establish the number of production VOC (Virgin Organic Coconut) based on the data supply and demand in KBU (main business region ) wootay coconut.With this approach, companies can plan the production of voc efficiently and can also compare actual data to research data.

## 2. RESEARCH METHOD

Fuzzy system is a system formed from existing knowledge. The e of this system lies in the rule base consisting of fuzzy IF-THEN rules. In these rules, the IF-THEN statements are represented by words connected to membership functions. The initial process in building a fuzzy system involves gathering

a collection of fuzzy IF-THEN rules from the relevant knowledge domain. A fuzzy set A in the universe of discourse S can be characterized by the membership function $\mu_A(x)$ which assigns $x \in S$ a degree of membership $\mu_A(x) \in \{0,1\}$. Ant element $x \in S$ is said to be in the fuzzy set A if and only if $\mu_A(x) > 0$ and is considered a full member if and only if $\mu_A(x) = 1$.[2][3][4]

In this study, to depict the membership function curves, triangular curves (refer to figure 1) and trapezoidal curves (refer to figure 2) are utilized

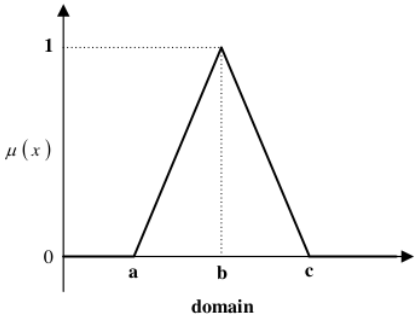
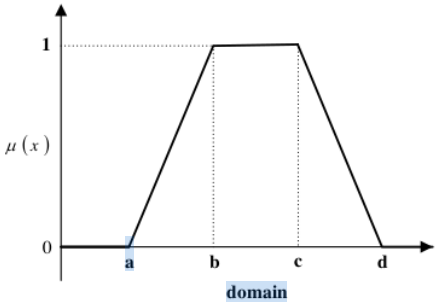



Figure 1. The triangular curve

Membership function :

$$\mu(x) = \begin{cases} 0; & x \le a \text{ or } x \ge c \\ \dfrac{(x-a)}{(b-a)}; & a \le x \le b \\ \dfrac{(b-x)}{(c-b)}; & b \le x \le c \end{cases}$$




Fugure 2. The trapezoidal curve

Membership Function :

$$\mu(x) = \begin{cases} 0; & x \le a \quad or \quad x \ge d \\ \dfrac{(x-a)}{(b-a)}; & a \le x \le b \\ 1; & b \le x \le c \\ \dfrac{(d-x)}{(d-c)}; & c \le x \le d \end{cases}$$

### 2.1 Fuzzy Rule Base

The fuzzy rule base consists of IF-THEN fuzzy rules and is the core of the fuzzy system in the sense that all other components are used to implement these rules sensibly and effectively [5][6][7] [8]The fuzzy rule base comprises the following IF-THEN fuzzy rules

$$Ru^{(l)} IF\ x_1\ is\ A_1^l\ and\ \cdots and\ x_n\ is\ A_n^l,\ THEN\ y\ is\ B^l \quad (1)$$

### 2.2 The Mamdani Fuzzy Method

The Mamdani method is one of the most common methods used in fuzzy logic applications. The Mamdani method refers to the process of inference or drawing conclusions from rules defined in the form of IF-THEN statements. In this method, input and output variables are expressed as fuzzy sets with predefined membership functions[3][9][8].

The steps of the Mamdani method are as follows:

1. Fuzzification involves converting each variable from crisp values to fuzzy sets using membership functions [9], [10].
2. IF-THEN rules refer to predefined fuzzy rules using AND and OR operators on fuzzy input sets to generate fuzzy output sets.
3 Aggregation involves combining the fuzzy output sets from each rule into a single fuzzy set.
4. Defuzzification is the process of converting the fuzzy output set into a crisp value that can be used in decision-making. In this research, defuzzification uses the Center of Gravity Defuzzifier (Centroid) model as seen in equation 2. The mapping from a fuzzy set within $U$ as the output from the fuzzy inference engine to a point $y^*$ in $V$ where $y$ is crisp.

$$y^* = \frac{\int_y \mu_B'(y).ydy}{\int_y \mu_B'(y)dy} \quad (2)$$

### 2.3 The Sugeno Fuzzy Method

The Sugeno fuzzy method has the characteristic that the consequent part is not a fuzzy set but a constant value or a linear equation with variables corresponding to its input variables. The Sugeno model used in this research is the Sugeno Order-0 model for fuzzy inference systems [11], [12][13]. Here is the general form of the Sugeno Order-0 fuzzy model:

$$IF(x_1 is\ A_1)o(x_2 is\ A_2)o\ \dots\ o(x_n is\ A_n)THEN\ z = k \quad (3)$$

Where $A_i$ is the fuzzy set for the i-th antecedent, o is a fuzzy operator (such as AND or OR), and k is a constant (crisp) as the consequent.

## 3. RESULT AND DISCUSSION

### 3. 1 Research Data

In this research, VOC (Volatile Organic Compounds) data was collected from KBU (Wootay Coconut) in Central Maluku Regency. The data collected spans from January to December 2022. The data to be processed using fuzzy logic consists of each month's data to enable the company to plan the amount of VOC production for the following month. The formation of fuzzy sets for input variables is divided into two: inventory and demand, while the output variable is production. The domains for each variable can be seen in Table 1 below

Table 1. VOC Inventory Data

| Function | Variable | Domain |
|---|---|---|
| Input | inventory | 50-210 |
| | demand | 100-1000 |
| Output | production quantity | 300-1100 |

### 3. 2 Fuzzifikasi

To calculate the quantity of VOC production using the Mamdani fuzzy logic, a fuzzification process is performed to convert crisp values into fuzzy values for each fuzzy set (Low, Medium, High) using membership functions for input and output variables. Figure 1 displays the membership functions for the demand input variable. Meanwhile, the membership function for the inventory input variable can be seen in Figure 2, and Figure 3 shows the membership functions for the output variable, Production. As for the Sugeno fuzzy method, it can be demonstrated for the output variable, production result, with given constant values.

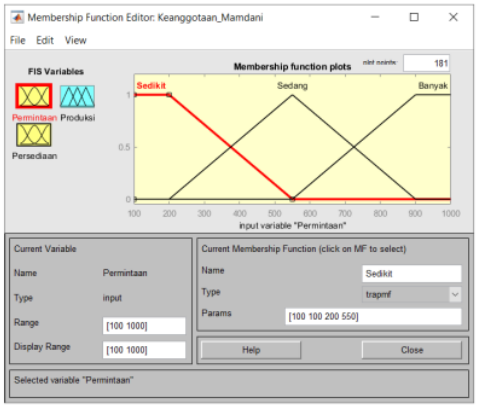



Figure 1. Membership Functions for Demand

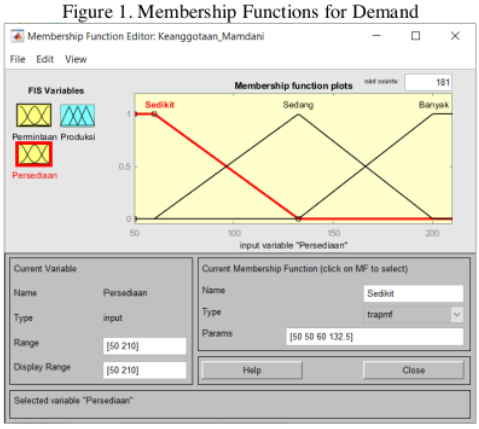



Figure 2. Membership Functions for inventory

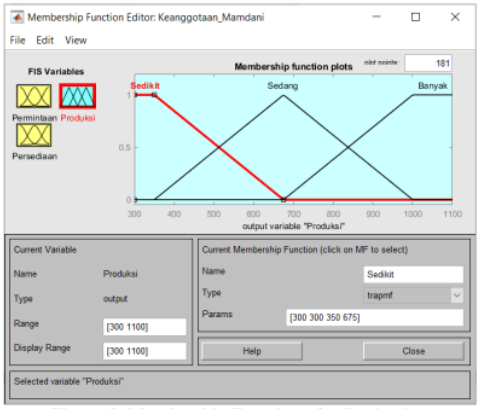
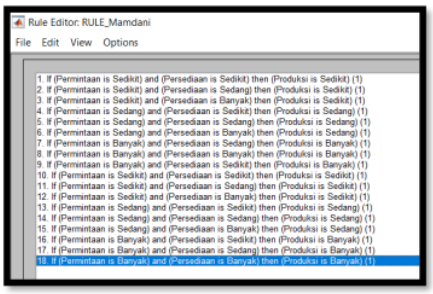



Figure 3. Membership Functions for Production


Figure 4. Constant Values for the Production Output Variable

### 3.3 Rule IF-THEN

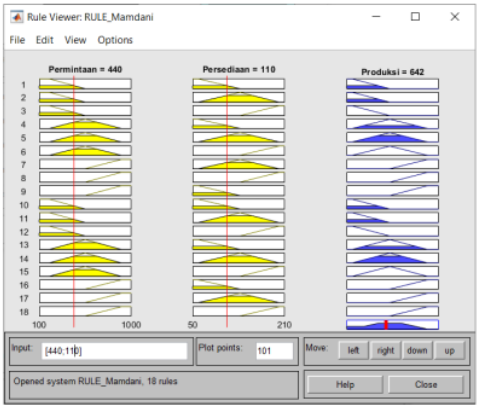
For the IF-THEN rules in both Mamdani and Sugeno fuzzy logic, 18 fuzzy rules are employed, utilizing AND and OR operators, to obtain the best result for the quantity of VOC production. The fuzzy rules can be observed in Figure 5 below.




Figur 5. Rule Base Fuzzy

### 3.4 Defuzzifikasi

Through the IF-THEN process, the results of the defuzzification process using the Mamdani method can be observed, where fuzzy values have been transformed into crisp values. For instance, when there's a demand for 440 liters of VOC and only 110 liters available in inventory, the required production quantity amounts to 642 liters. The defuzzification process is depicted in Figure 6. Regarding the Sugeno fuzzy logic, when the demand and inventory values are the same as in the Mamdani fuzzy logic, the required VOC production amounts to 624 liters. For a clearer view, please refer to Figure 7 below.




Fugure 6. The production result using Mamdani fuzzy logic


Figure 7. The production result using Sugeno

### 3.5 Mean Absolute Percentage (MAPE)

When the fuzzy results have been obtained using the Mamdani and Sugeno fuzzy models, the next step is to measure the accuracy of each obtained result. The Mean Absolute Percentage Error (MAPE) for this study is calculated using the data for each month.

## 4. CONCLUSION

Based on the results and discussions conducted, it can be concluded that with the actual data of VOC production results at KBU Wootay Coconut in 2022, the Sugeno fuzzy model performed better than the Mamdani fuzzy model. This was evident during the process involving 18 fuzzy rules using AND and OR operators for each fuzzy set and IF-THEN rules for each input variable: demand (low, medium, high), inventory (low, medium, high), and output (low, medium, high). What strengthens the conclusion that Sugeno fuzzy logic is superior to Mamdani fuzzy logic with this data is that the MAPE for Sugeno fuzzy logic has a value of 36.11%, with an accuracy level of 63.89%, while for Mamdani fuzzy logic, the MAPE value is 38.77%, with an accuracy level of 61.23%. With the obtained MAPE values from Mamdani and Sugeno fuzzy logic, the forecast for producing VOC at KBU Wootay Coconut is viable using the Sugeno fuzzy logic.

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