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

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Abstract

In the future, there will be tight industrial competition. Professional management companies become crucial to being successful and competitive on the global market. One of the key factors in production is the ability to plan and optimize the production process of goods. To face fluctuations in 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), and output (little, medium, a lot). 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 of 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 VCO, Demand, Supply*

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1. INTRODUCTION

In the era of globalization, industrial competition is becoming very strict. Professional skills in managing a company become crucial to success in such a competitive global market. One of the key aspects of production is the ability to plan and optimize the production process of goods.

Maximum profit depends on maximum sales. Maximum sales means meeting all existing demands. If a company produces less than demand, the opportunity for optimal profit will be missed. On the contrary, if production exceeds demand, a company will face losses, then production planning within the company is crucial to respond to market demand accurately. Factors like supply and demand are key in optimizing production.

One of the methods used by a company in designing and managing the output of production is linear programming [1]. However, when it is different when you want to know the quantity of production that does not necessarily know the actual amount of production then by [2] applying the Mamdani and sugeno methods in fuzzy logic, the company can make a predictive plan to determine the volume of production by considering the data of existing supply and demand from the company. This approach allows companies to optimize in maximizing profits by producing quantities of goods that meet customer demands.

In the face of consumer demand fluctuations without adding existing supplies, companies can use the fuzzy Mamdani and Sugeno methods to determine the amount of production of VOCs (Virgin Organic Coconut) based on stock and demand data in Wootay Coconut. With this approach, firms can plan VOC production efficiently and compare actual data with research data.

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2. RESEARCH METHOD

A fuzzy system is a system that is formed from existing knowledge. The core of this system lies on the basis of rules consisting of IF-THEN rules. In these rules, IF-THEN statements are represented by words associated with membership functions. The initial process in building a fuzzie system is to collect a set of IF-THEN rules from the relevant domain of knowledge. A fuzzy set A in the universe S can be characterized by the membership function $\mu_A(x)$ which sets $x \in S$ to a degree of membership $\mu_A(x) \in \{0,1\}$. An element $x \in S$ is said in the fuzzy set A if and only if $\mu_A(x) > 0$ and is considered a full member if and only if $\mu_A(x) = 1$.[3][4][5]

In this study, to describe the function curve of gravity used the triangular curves (see figure 1) and trapezium curves (see figure 2).

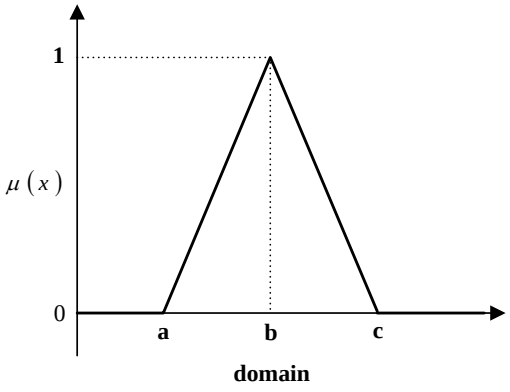
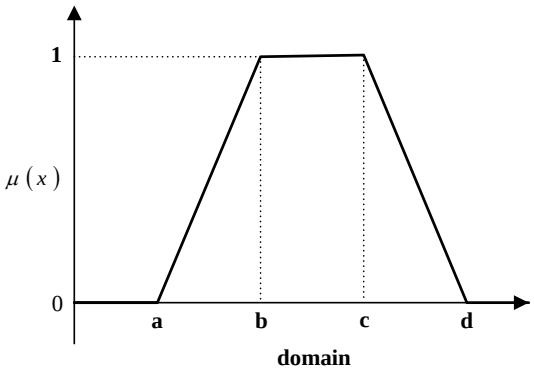


Figure 1. The Triangular Curve

Membership Function :

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



Fugure 2. The Trapezium 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 Base Rule

The base of fuzzy rule 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 [6][7][8][8]. The base of fuzzy rule includes the following IF-THEN fuzzy rules

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

2.2 The Fuzzy Mamadani 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 make conclusions from the rules defined in IF-THEN statements. In this method, the input and output variables are expressed in the form of a fuzzy set with a specified membership function [4][10][9]. The steps of the Mamdani method are as follows:

1. Fuzzification means that each variable of a crisp value is converted into a fuzzy set using a membership function [10], [11] [12].
2. The IF-THEN rule is a fuzzy rule that has been specified with the AND and OR operators on the Fuzzy input set to generate the FUZZY output set.
3. Aggregation is a set of fuzzy outputs of each rule combined into one set.
4. Defusification is a fuzzy set of outputs converted to a firm value in the form of a crisp that can be used in decision-making. In this study defusification uses the model Center of gravity defuszifier (Cedroid) seen on equation 2. Mapping of a fuzzy sets within *U* as the output of the Fuzzy inference system into a point *y** in *V* where *y* is crisp.

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

2.3 The Fuzzy Sugeno 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 Fuzzy Sugeno model used in this research is the Sugeno Order-0 model for fuzzy inference systems [13], [14][15]. Here is the general form of the fuzzy Sugeno Order-0 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**.** [16]

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 was taken from January to December 2022. The data that will be processed with fuzzy is the data of each month so that the company can plan the amount of VOC production for the next month. The formation of a fuzzy set for input variables is divided into two: supply and demand, whereas the output variables are production. The domains for each variable can be seen in Table 1 below.

Table 1. VOC's Stock Data

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

3. 2 Fuzzification

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 3 displays the membership functions for the demand input variable. Meanwhile, the membership functions for the inventory input variable can be seen in Figure 4, Figure 5 membership function for production and Figure 6 show that the membership functions from the output variable as a Production. And then, the Sugeno fuzzy method can be demonstrated for the output variable as production result, with given constant values.

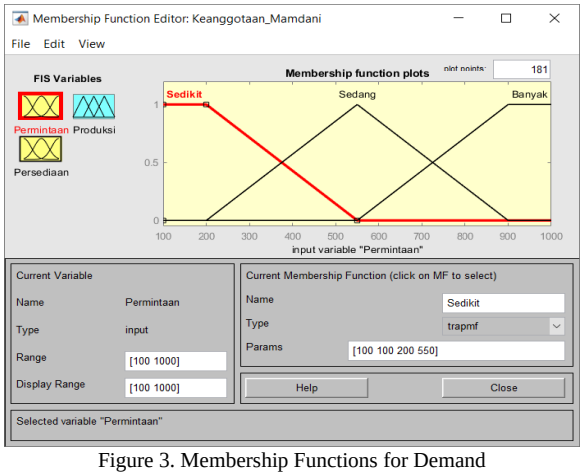


Figure 3. Membership Functions for Demand

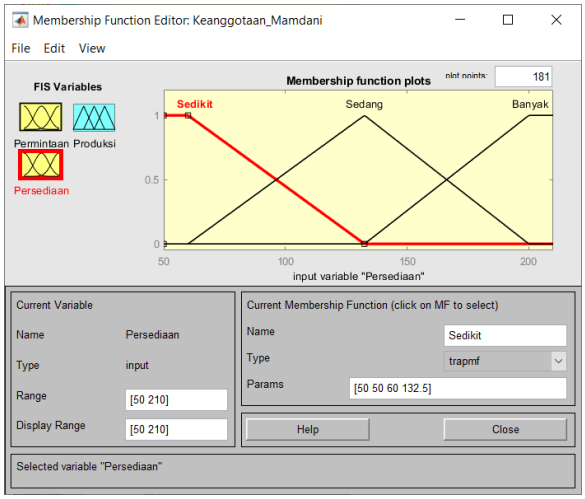


Figure 4. Membership Functions for Inventory

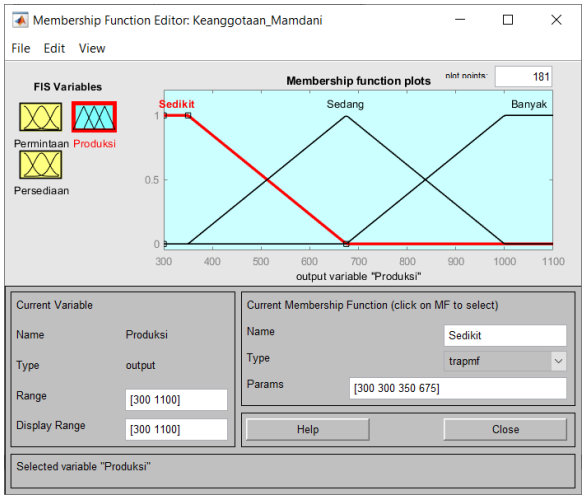


Figure 5. Membership Functions for Production

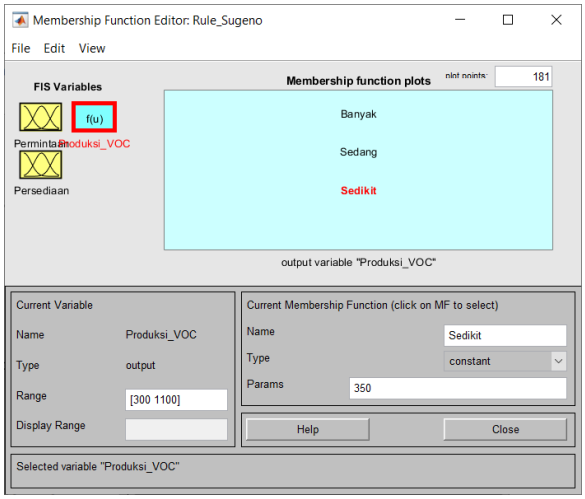
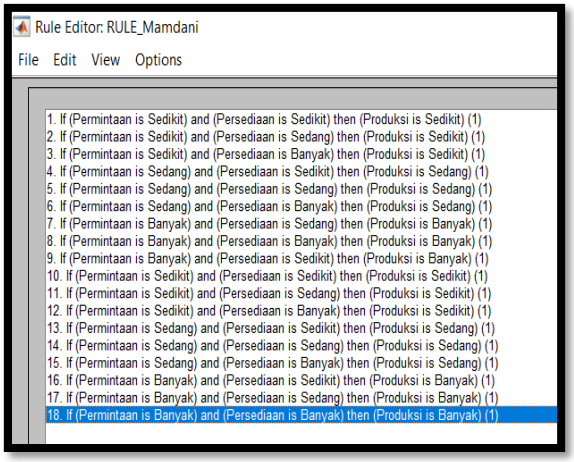


Figure 6. Constant Values for the Production Output Variable

3.3 Rule IF-THEN

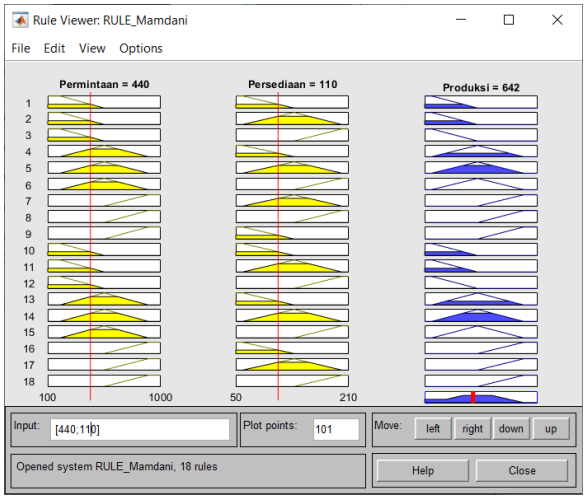
For the IF-THEN rules in both Mamdani and Sugeno fuzzy logic, 18 fuzzy rules are employed, utilizing AND and OR operators, to obtain the best result for the quantity of VOC production. The fuzzy rules can be observed in Figure 7 below.



Figur 7. Fuzzy Base Rule

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 example, when there is a demand for 440 liters of VOC and only 110 liters available in inventory, the required production quantity amounts to 642 liters. The defusification process can be shown in Figure 6, whereas for fuzzy sugeno, when the value of demand and supply is the same as in fuzzy mamdani, then the VOC to be produced is 624 liters.The defuzzification process is depicted in Figure 8. So, the result obtained are shown on Figure 9 as follows:



Fugure 8. The Production Result using Mamdani Fuzzy Logic

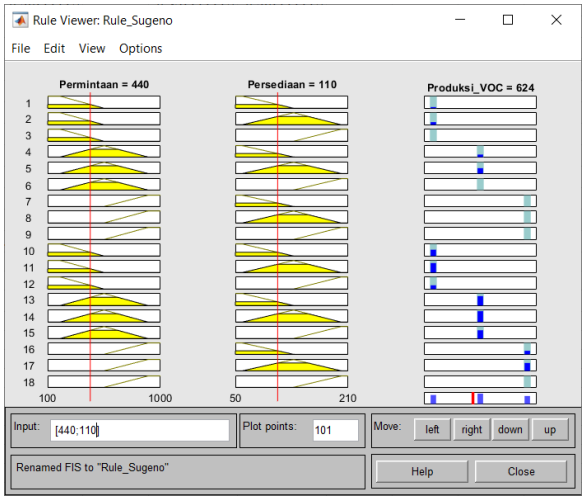


Figure 9. The Production Result using Sugeno Fuzzy Logic

3.5 Mean Absolute Percentage (MAPE)

When the fuzzy result has been obtained with the Fuzzy model of Mamdani and Sugeno, then the next process is to measure the accuracy of each result. The results of MAPE on this study are taken from each month's data.

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.

5. REFERENCES

[1] M. Mujiono and S. Sujianto, "Implementasi Metode Optimalisasi Jumlah Produksi Dengan Menggunakan Linier Programming," *Ind. Inov. J. Tek. Ind.*, vol. 10, no. 2, pp. 65–69, 2020, doi : 10.36040/industri.v10i2.2797.

[2] K. Muflihunna and M. Mashuri, "Penerapan Metode Fuzzy Mamdani dan Metode Fuzzy Sugeno dalam Penentuan Jumlah Produksi," *Unnes J. Math.*, vol. 11, no. 1, pp. 27–37, 2022, 10.15294/ujm.v11i1.50060.

[3] D. Upuy, F. Leunupun, Y. A. Lesnussa, Z. A.

Leleury, and A. H. Hiariey, "Application of Fuzzy Logic to Find Out the Amount of Spending Money at the Bank," *Formosa J. Comput. Inf. Sci.*, vol. 1, no. 2, pp. 133–142, 2022, 10.55927/fjcis.v1i2.2156.

[4] D. P. P. Astuti and Mashuri, "Penerapan Metode Fuzzy Tsukamoto dan Fuzzy Sugeno Dalam Penentuan Harga Jual Sepeda Motor," *UNNES J. Math.*, vol. 1, no. 2252, pp. 75–84, 2020, 10.15294/ujm.v9i2.33434.

[5] A. Rahman Hakim, "Penerapan Logika Fuzzy Untuk Menentukan Harga Jual Tas Fashion Menggunakan Metode Sugeno," *J. Desain Dan Anal. Teknol.*, vol. 2, no. 1, pp. 84–91, 2023, 10.58520/jddat.v2i1.24.

[6] D. Upuy and R. Wardoyo,"IMPLEMENTASI QUERY FUZZY PADA BASIS DATA RELASIONAL, DIKE, UGM, Yogyakarta, Indonesia, 2017.

[7] R. E. Subarja and B. Hendrik, "Research Article Padangsidimpuan Utara Menggunakan Pendektan Fuzzy Inference," vol. 1, pp. 90–95, 2023, 10.31004/green.v1i3.17.

[8] S. Auliana and U. Mansyuri, "Penggunaan Metoda Fuzzy Tsukamoto Untuk Menentukan Produksi Barang Elektronik 1," *J. Simasi J. Ilm. Sist. Inf.*, vol. 2, no. 2, pp. 123–129, 2022, 10.46306/sm.v2i2.29.

[9] L. Susanti, "Analisis Kepuasan Pelanggan terhadap Kualitas Produk dan Pelayanan dengan Menggunakan Komparasi Fuzzy Inference System," *J. Sos. Teknol.*, vol. 2, no. 4, pp. 378–386, 2022, 10.59188/jurnalsostech.v2i4.329

[10] N. Setyanugraha, S. Al Aziz, I. W. Harmoko, and F. Fianti, "Study of a Weather Prediction System Based on Fuzzy Logic Using Mamdani and Sugeno Methods," *Phys. Commun.*, vol. 6, no. 2, pp. 61–70, 2022, 10.15294/physcomm.v6i2.39703.

[11] D. Rifai and F. Fitriyadi, "Penerapan Logika Fuzzy Sugeno dalam Keputusan Jumlah Produksi Berbasis Website," *Hello World J. Ilmu Komput.*, vol. 2, no. 2, pp. 102–109, 2023, 10.56211/helloworld.v2i2.297.

[12] dodi nofri yoliadi, "a Fuzzy-Based Expert System for Determinants of Teacher Performance," *JIKO (Jurnal Inform. dan Komputer)*, vol. 6, no. 1, pp. 28–35, 2023, 10.33387/jiko.v6i1.5796.

[13] R. Adrial, "Fuzzy Logic Modeling Metode Sugeno Pada Penentuan Tipe Diabetes Melitus Menggunakan MATLAB," *J. Ilm. Inform.*, vol. 6, no. 1, pp. 62–68, 2018, 10.33884/jif.v6i01.423.

[14] A. Siti, "Analisis komparasi metode tsukamoto dan sugeno dalam prediksi jumlah siswa baru," *J. Teknol. Inf. dan Komun.*, vol. 8, no. 2, pp. 57–63, 2016, 10.31294/bi.v4i1.537.

[15] A. Puspitasari and H. Zakaria, "Sistem Informasi Aplikasi Penentuan Jurusan Yang Sesuai Dengan Minat Menggunakan Pendekatan Fuzzy Sugeno (Studi Kasus : SMK Fadilah)," vol. 1, no. 3, pp. 630–642, 2023.

[16] W. J. Chang, C. L. Su, and C. C. Ku, "Passive Decentralized Fuzzy Control for Takagi-Sugeno Fuzzy Model Based Large-Scale Descriptor Systems," *IEEE Access*, vol. 10, pp. 28656–28669, 2022, 10.1109/ACCESS.2022.3158671.