

Prediction of Carang Mas Production Amount Using the Tsukamoto Fuzzy Inference System Method

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Abstrak—UD. ASTER adalah perusahaan yang bergerak di bidang usaha pengolahan makanan berbasis sumber daya alam yang berlokasi di kawasan wisata Sarangan yang terkenal di Magetan, Provinsi Jawa Timur. Carang Mas merupakan salah satu jenis olahan masakan berbahan dasar tanaman ubi jalar yang biasa dijual sebagai oleh-oleh di Sarangan untuk wisatawan. Pelaku industri menghadapi permintaan yang tidak dapat diprediksi. Saat ini perencanaan produksi dan pembuatan Carang Mas masih mengandalkan perhitungan manual sehingga menyebabkan terjadinya kelebihan produksi dan penumpukan barang. Daya tahan Carang Mas dalam situasi ini hanya sebatas sekitar satu bulan. Keberlanjutan perusahaan sangat dipengaruhi oleh ketidakpastian permintaan sehingga diperlukan penerapan sistem prediksi keluaran Carang Mas setiap bulannya. Sistem prediksi ini menggunakan pendekatan Fuzzy Tsukamoto karena kesesuaiannya dengan input dasar dan sedikit kebutuhan komputasi. Variabel inputnya adalah permintaan, stok, dan biaya produksi, sedangkan variabel outputnya adalah produksi. Outcome sistem merupakan perkiraan volume keluaran Carang Mas yang dicapai dengan teknik Fuzzy Tsukamoto. Efisiensi algoritma dapat diklasifikasikan sebagai $O(1)$ dalam notasi O Besar, yang menunjukkan kompleksitas waktu yang konstan. Uji MAPE menunjukkan nilai 4,0868 ketika membandingkan hasil aktual dengan hasil yang diharapkan dari Januari 2021 hingga Desember 2022.

Kata Kunci: Carang Mas, Metode Tsukamoto, Permintaan, Prediksi, Produksi

Abstract— UD. ASTER is a company in the natural resource-based food processing business located in the renowned Sarangan tourism area in Magetan, East Java Province. Carang Mas is a type of processed cuisine made from sweet potato plants, commonly sold as a souvenir in Sarangan for tourists. Industry participants are encountering unpredictable demand. Currently, production planning and manufacturing of Carang Mas still rely on manual calculations, leading to overproduction and an accumulation of items. Carang Mas' endurance in this situation is limited to around one month. The company's sustainability is significantly impacted by demand unpredictability, necessitating the implementation of a predictive system for Carang Mas output every month. This prediction system utilizes the Fuzzy Tsukamoto approach because of its suitability for basic input and few computational requirements. The input variables are demand, stock, and manufacturing costs, with the output variable being production. The system's outcome is a forecast of Carang Mas output volumes achieved by the Fuzzy Tsukamoto technique. The algorithm's efficiency can be classified as $O(1)$ in Big O notation, indicating constant time complexity. The MAPE test revealed a value of 4.0868 when comparing actual outcomes with expected results from January 2021 to December 2022.

Keywords: Carang Mas, Tsukamoto Method, Demand, Prediction, Production

1. INTRODUCTION

Carang Mas is a traditional dish from Magetan made with sweet potatoes and Javanese sugar, known for its sweet and savory flavor and distinctive shape. UD.ASTER, a participant in the Carang Mas industry, is located in Plaosan sub-district, Magetan Regency.

The time-constrained nature of Carang Mas, with a maximum shelf life of one month, poses challenges for industry participants if the product is not promptly sold or becomes out of stock. This will undoubtedly affect the ongoing operations of the industry participants. An issue commonly encountered in Carang Mas production is the challenge of determining the optimal production quantity. Excessive production leads to surplus inventory, while insufficient production fails to meet sales targets, causing market demand fluctuations. Producers must forecast the quantity of things to be manufactured to prevent this issue.

Forecasting the quantity of goods to be manufactured will affect the company directly. If output is kept at an appropriate level, it will not result in future losses. Thus, corporations or industrial entities require a production system capable of forecasting production volumes.

A fuzzy inference system is a mechanism that producers can utilize to forecast or determine the quantity of things to be produced. The "Fuzzy Inference System" is a method of creating a mapping from input to output by utilizing fuzzy logic. Fuzzy logic is a key element of soft computing, initially established by Prof. Lotfi A. Zadeh in 1965 [1]. Fuzzy logic is utilized to translate issues from input to anticipated output.

Current studies on Carang Mas focus on enhancing productivity [2], providing management support [3], evaluating production costs [4], and doing profit and loss analysis [5]. Regarding projections, [6] employed Fuzzy Tsukamoto to forecast bread production, while [7] utilized the same method to predict cat rice production based on characteristics such as visits, sales, and remaining production. [8] quantified Palm Oil production utilizing Fuzzy Mamdani. [9] used Fuzzy Tsukamoto to forecast oyster mushroom production based on sales, inventories, and manufacturing variables.

Currently, there is a lack of studies on predictive methods for estimating Carang Mas output levels. In Carang Mas, the prediction of production amount is based on three input variables: demand, stock, and production costs. The output variable is production.

3. RESEARCH METHODS

2.1 Forecast

Prediction is the methodical practice of estimating something to reduce errors or discrepancies between expectations and reality [10][11]. Prediction is the act of forecasting future events by analyzing data from previous and current occurrences. Fuzzy theory was developed to aid with predicting by utilizing a mathematical approach to examine future conditions. The predicted outcome may not necessarily be an exact eventuality, but it can provide an answer that is nearly accurate or closely resembles reality [12]. Forecasts can be categorized into two parts: qualitative and quantitative forecasts.

Qualitative predictions rely on the subjective judgment or expertise of the predictor, and the accuracy of these forecasts is solely determined by the predictor. Quantitative forecasts are influenced by the method utilized, with each method yielding different results. The method that is considered to be accurate accounts for potential variations in deviations or values [13].

2.2 Manufacturing

Production is the process of increasing the value of commodities and services. Currently, production is essential in an industry [14][15]. Carang Mas production in Magetan, East Java is notably high, with Plaosan District being the area with the most producers. There are 30 Carang Mas business units in Plaosan District, and Bulugunung Village stands out as one of the villages with the highest Carang Mas production. Over 200 households in Bulugunung Village are known for producing Carang Mas snacks.

2.3 Carang Mas

Carang Mas is a classic snack that is cooked in a straightforward manner. The potential of Carang Mas in the Magetan district is significant in boosting UMKM in the area [2], [16]. This classic dry snack, featuring a blend of sweet and salty tastes, is crafted from sweet potatoes and brown sugar. Magetan Regency in East Java Province has established several minor food companies, with Carang Mas being a prominent one known for its high output value. The industrial activity in Magetan, namely Carang Mas, demonstrates promising potential. Carang Mas is prepared by combining sweet potatoes with brown sugar. Carang Mas production begins by peeling the skin off sweet potatoes. The sweet potato has been peeled and grated. The sweet potatoes are then steeped for around 20 minutes. After soaking, proceed to cook the sweet potatoes until they turn a light brownish-yellow color. Subsequently, heat the brown sugar until it liquefies. Combine it with the previously sautéed sweet potato and stir until it dissolves uniformly. The subsequent action involves printing based on the size. Once dried, it can be packaged promptly [17]. The Carang Mas snack can remain fresh for about one month when sealed in an airtight package.

2.2 Fuzzy Logic

Professor Lotfi A. Zadeh discovered fuzzy logic in 1965. A statement can have a truth value that varies from entirely false to entirely truthful. An object can belong to multiple sets with varying degrees of membership in each set [18]. Fuzzy logic functions as a link, frequently referred to as a black box, connecting the output to the input. Refer to Figure 1 [19] for additional information.

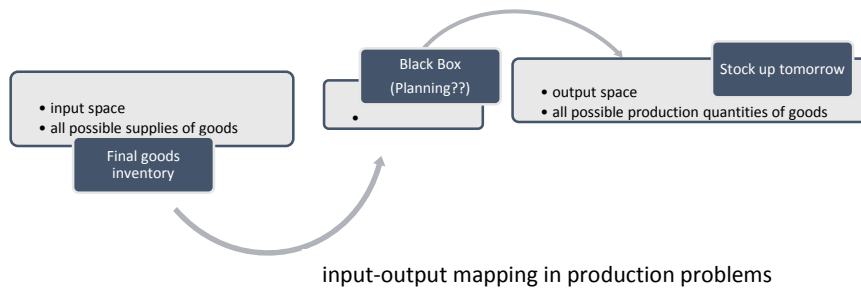


Figure 1. Input-Output Mapping

The "Fuzzy Inference System" is a method of creating a mapping from input to output by utilizing fuzzy logic [15]. Fuzzy logic is a form of logic that deals with imprecise values, which are not entirely accurate, uncertain, or represent a degree of truth. Fuzzy logic is utilized because of its straightforward mathematical framework, making it easily comprehensible and allowing for imprecise data. The researcher employs the Tsukamoto technique, which models each consequence of the rules in the IF-THEN form using fuzzy sets and the same membership function [20]. Researchers utilize the Tsukamoto approach due to its tolerance for the data being investigated, intuitive advantages, and ability to deliver solutions to ambiguous or erroneous data [21].

Reasons for utilizing fuzzy logic include its simplicity, ability to handle imprecise data, capacity to model complex non-linear relationships, incorporation of experiential knowledge, and compatibility with generic applications [22].

What must be comprehended regarding fuzzy systems, as stated in reference [23] ;

- a) Variables. Variables employed in the fuzzy system. Examples cost, demand.
- b) Define. Specific categories symbolize the factors that will be utilized. Example: variables of varying sizes - small, medium, and giant.
- c) Speaker domain. The real numbers, whether negative or positive, represent the value of a variable when arranged from left to right.
- d) Domains. The speaker's universe assigns a value that can be utilized for an operation.

Fuzzy logic employs a rule in fuzzy sets that are depicted as "IF <Fuzzy Proposition> THEN <Fuzzy Proposition>". Propositions are categorized into two types: atomic propositions and compound propositions. An atomic proposition consists of a single statement where x is a linguistic variable and A is a fuzzy set x . On the other hand, a complex fuzzy proposition is formed by combining fuzzy atomic propositions using the operators "or" and "not" [24].

Figure 2 displays the research stages, which include problem identification for predicting Carang Mas production, data collection on demand, stock, and production costs monthly, method selection and fuzzy analysis application, system development, and implementation. The last stage involves implementing the process to obtain anticipated outcomes.

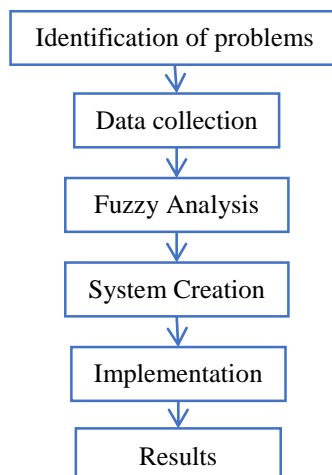


Figure 2. Research Steps

Figure 3 illustrates the Carang Mas production forecast system flow. The process commences with a login page where users input their username and password. Incorrect data input will prompt the system to restart. Valid data can be used to input demand, stock inventories, and production costs, which are then processed to provide expected production numbers. If yes, conclude by logging out.

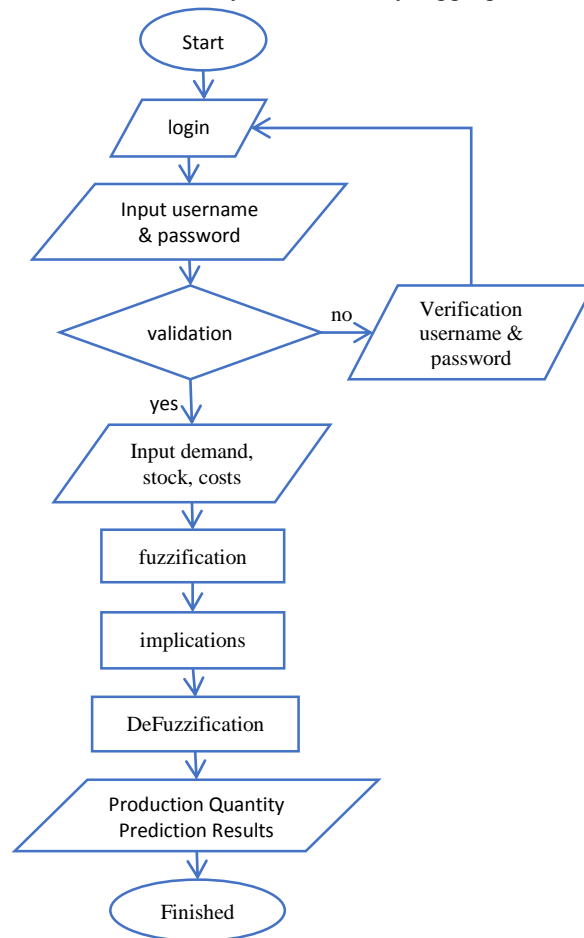


Figure 3. Prediction System Flowchart

Figure 4 illustrates the procedure for utilizing Fuzzy Tsukamoto.

Tsukamoto's Fuzzy Method starts by creating a fuzzy set from the variables used, a process known as fuzzification. Fuzzification involves creating a set by defining the membership function. Next, establish the IF-THEN rules. Identify implications and then establish rules and defuzzification. Defuzzification is the process of deriving crisp output values from the fuzzy inference outcomes of each rule, based on α -predicates, by employing a weighted average [25].

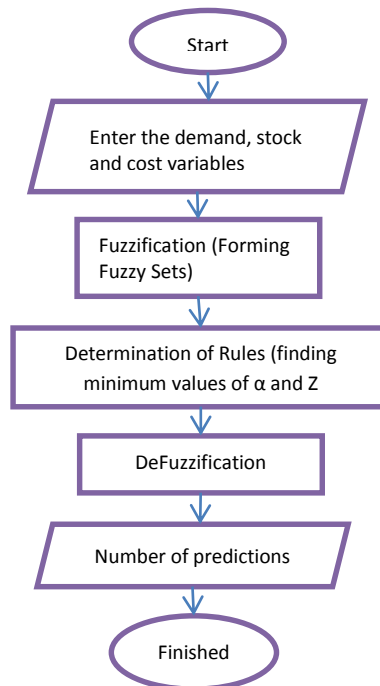


Figure 4. Displays the Algorithm Flowchart

Three input variables, demand, stock, and production costs, are utilized to forecast production amounts. Demand variable represents the monthly sales target, stock variable denotes the remaining product after sales, and the production cost variable signifies the costs associated with creating items each month. The steps involved in utilizing the Fuzzy Tsukamoto Method are:

1. Fuzzification applied to each variable

Variables affecting demand

Comprises of two sets: DOWN and UP.

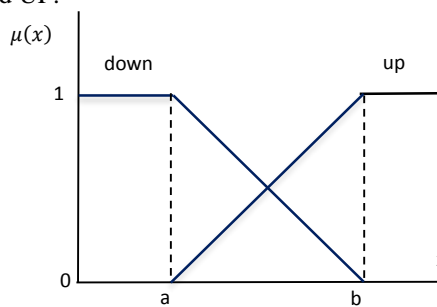


Figure 5. Membership Function for Demand Variables

$$\mu_{\text{Demand Down}}(x) = \begin{cases} 0 & x \geq b \\ \frac{b-x}{b-a} & a \leq x \leq b \\ 1 & x \leq a \end{cases} \quad (1)$$

$$\mu_{\text{Demand Rises}}(x) = \begin{cases} 0 & x \leq a \\ \frac{x-a}{b-a} & a \leq x \leq b \\ 1 & x \geq b \end{cases} \quad (2)$$

2. Formation of Rules

Table 1. Examples of Fuzzy rules

R	Input (IF)	Output (THEN)
Request	Cost Stock	Production

1	Down	A little	A little	Down
2	Down	A little	Lots	Down
3	Down	Lots	A little	Up
4	Down	Lots	Lots	Down
5	Up	A little	A little	Up
6	Up	A little	Lots	Down
7	Up	Lots	A little	Up
8	Up	Lots	Lots	Up

3. Tsukamoto's inference

Tsukamoto Fuzzy Inference uses the minimum implication function.

$$\alpha_1 = \min(\mu_a[x_1], \mu_b[x_2]) \quad (3)$$

With α as the predicate

$$\frac{z-a}{b-a} = \alpha_{\text{predikat}} \quad (4)$$

4. Defuzzification

The centralized average method is used

$$Z = \frac{\sum \alpha * z}{\sum \alpha} \quad (5)$$

Where α is the inference result and z is the output rule.

The Mean Absolute Percentage Error (MAPE)

MAPE is used as a measure of the accuracy of calculations in forecasting, if the resulting value is smaller, the accuracy figure will be higher. The following is the MAPE formula [26]:

$$MAPE = \frac{1}{n} \sum_{i=1}^n \left| \frac{A_i}{F_i} \right| \cdot 100\% \quad (6)$$

With n = amount of data; A_i = actual data value and F_i = predicted data value

The interpretation of MAPE itself can be seen in Table 2.

Table 2. Interpretation of MAPE Values

MAPE value	Interpretation
≤ 10	Accurate prediction results
10-20	Prediction results are good
20-50	Prediction results are quite good
≥ 50	Inaccurate prediction results

Algorithm Testing

In Algorithm testing, Big-o Notation is used to see the time complexity of an algorithm. In simple terms, Big-O notation is defined as a process starting from INPUT and then the final PROCESS, namely OUTPUT. Then, testing the algorithm is carried out by looking at the coding of the algorithm and then comparing it with several parameters from big O notation [27].

3. RESULTS AND DISCUSSIONS

The data used consists of demand, stock, production costs, and production data for 2021 to 2022 (table 3). Carang Mas is packaged/wrapped with 10 contents in each pack.

Table 3. Data 2021 to 2022

Year	Month	P	S	BP	Prd
2021	Jan	6000	0	19,272,000	5800
2021	Feb	6540	63	17,946,000	5650
2021	Mar	6825	44	19,936,000	6000
2021	Apr	6682	77	21,847,000	5950
2021	Mei	6850	15	19,936,000	6000
2021	Jun	5200	0	16,613,000	5000

2021	Jul	5500	50	19,120,000	5790
2021	Agt	6250	4	20,225,000	6250
2021	Sep	6660	30	21,764,000	6300
2021	Okt	6552	11	20,684,000	6225
2021	Nov	6500	57	20,268,000	6100
2021	Des	5500	13	18,607,500	5600
2022	Jan	6500	12	23,259,000	7000
2022	Feb	7025	56	17,112,000	5150
2022	Mar	6850	9	21,681,500	6525
2022	Apr	5430	10	18,358,000	5525
2022	Mei	5380	19	17,942,000	5400
2022	Jun	5350	57	16,800,000	5000
2022	Jul	5300	74	16,760,000	5470
2022	Agt	6750	0	21,250,000	6000
2022	Sep	5360	11	18,000,000	5000
2022	Okt	6000	10	20,000,000	6125
2022	Nov	6400	0	19,500,000	6100
2022	Des	5450	24	18,200,000	5600

Information: P = Demand in packs, S = Stock in packs, BP = Production Costs and Prd = Production in packs.

The variables used along with the universe of discussion are shown in table 4.

Table 4. Variables

Function	Variable name	Name of the set	Speaker universe
Input	request	Down	5,200
		Increase	7,025
	stock	Few	0
		Lots	77
	Production cost	Few	16,613,000
		Lots	23,259,000
Output	Production	Down	5,000
		Increase	7,000

Fuzzifikasi

1. Demand Variables

$$\mu_{\text{Demand Down}}(x) = \begin{cases} 0 & x \geq 7025 \\ \frac{7025 - x}{7025 - 5200} & 5200 \leq x \leq 7025 \\ 1 & x \leq 5200 \end{cases}$$

$$\mu_{\text{Demand Rises}}(x) = \begin{cases} 0 & x \leq 5200 \\ \frac{x - 5200}{7025 - 5200} & 5200 \leq x \leq 7025 \\ 1 & x \geq 7025 \end{cases}$$

2. Stock Variable

$$\mu_{\text{Stock few}}(x) = \begin{cases} 0 & x \geq 77 \\ \frac{77 - x}{77 - 0} & 0 \leq x \leq 77 \\ 1 & x \leq 0 \end{cases}$$

$$\mu_{\text{Stock lots}}(x) = \begin{cases} 0 & x \leq 0 \\ \frac{x-0}{77-0} & 0 \leq x \leq 77 \\ 1 & x \geq 77 \end{cases}$$

3. Variable Production Costs

$$\mu_{\text{Low Production Costs}}(x) = \begin{cases} 0 & x \geq 23.259.000 \\ \frac{23.259.000 - x}{23.259.000 - 16.613.000} & 16.613.000 \leq x \leq 23.259.000 \\ 1 & x \leq 16.613.000 \end{cases}$$

$$\mu_{\text{Large Production Costs}}(x) = \begin{cases} 0 & x \leq 16.613.000 \\ \frac{x - 16.613.000}{23.259.000 - 16.613.000} & 16.613.000 \leq x \leq 23.259.000 \\ 1 & x \geq 23.259.000 \end{cases}$$

4. Production Variables

Figure 8. production function

$$\mu_{\text{Production Down}}(z) = \begin{cases} 0 & z \geq 7000 \\ \frac{7000 - z}{7000 - 5000} & 5000 \leq z \leq 7000 \\ 1 & z \leq 5000 \end{cases}$$

$$\mu_{\text{Production goes up}}(z) = \begin{cases} 0 & z \leq 5000 \\ \frac{z - 5000}{7000 - 5000} & 5000 \leq z \leq 7000 \\ 1 & z \geq 7000 \end{cases}$$

Based on the data in table 1 and the discussion universe in table 2, if implemented, the results in table 5 and table 6 will be obtained.

Table 5. Results of Calculating Membership Functions for Demand and Stock Variables

Year	Month	Request		Stock	
		μ_{down}	μ_{increase}	μ_{few}	μ_{lots}
2021	Jan	0,561644	0,438356	1,000000	0,000000
2021	Feb	0,265753	0,734247	0,181818	0,818182
...
2022	Mar	0,095890	0,904110	0,883117	0,116883
2022	Apr	0,873973	0,126027	0,870130	0,129870
...

Table 6. Results of Calculating Membership Functions for Production and Production Cost Variables

Year	Month	Production cost		Production	
		μ_{few}	μ_{lots}	μ_{down}	μ_{increase}
2021	Jan	0,599910	0,400090	0,600000	0,400000
2021	Feb	0,799428	0,200572	0,675000	0,325000
...
2022	Apr	0,737436	0,262564	0,737500	0,262500

2022	Mei	0,800030	0,199970	0,800000	0,200000
...

Next, using the fuzzy inference formula and rule (table 1) we get the predicate α (equation 4), then using equation 5 we get the prediction results (table 7).

Table 7. Prediction Results

Year	Month	$\sum \alpha$	$\sum \alpha * z$	Z
2021	Jan	1,800181	10945,78	6080,38
2021	Feb	2,128416	13254,05	6227,19
2021	Mar	2,295499	14237,72	6202,45
...
2021	Mei	1,773172	11186,85	6308,95
2021	Jun	1	5000,00	5000,00
...

A comparison between the predicted results and the actual numbers is shown in Figure 6.

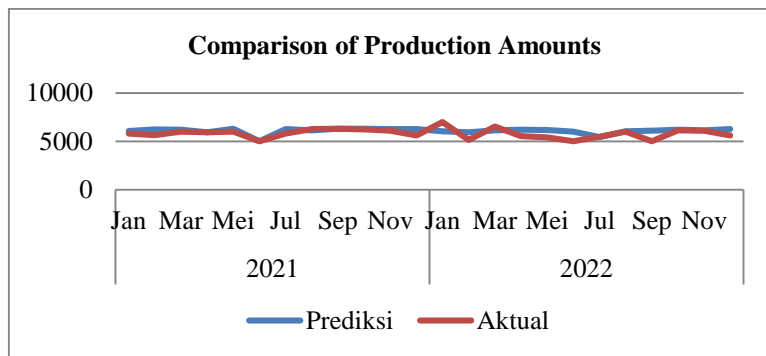


Figure 6. Comparison of Actual and Predicted Results

3.1 System Implementation

Implementation of a production quantity prediction system at UD. ASTER uses the Fuzzy Tsukamoto method as in Figure 7 which displays the home menu.



Figure 7. Home Menu

In the home menu, there is a welcome greeting and a photo of the product that will be predicted.

No	Produk	Bulan	Tahun	Permintaan	Biaya Produksi	Stok	Produksi	Aksi
1	CarangMas	JANUARI	2021	600	337200	0	900	[Add] [Delete]
2	CarangMas	FEBRUARI	2021	640	309600	63	100	[Add] [Delete]
3	CarangMas	MARET	2021	625	399800	44	900	[Add] [Delete]
4	CarangMas	APRIL	2021	662	228700	77	675	[Add] [Delete]
5	CarangMas	MAY	2021	600	399800	15	600	[Add] [Delete]
6	CarangMas	JUNI	2021	530	386200	0	500	[Add] [Delete]
7	CarangMas	JULI	2021	500	220200	50	600	[Add] [Delete]
8	CarangMas	AGUSTUS	2021	620	214000	4	940	[Add] [Delete]
9	CarangMas	SEPTEMBER	2021	660	207400	30	650	[Add] [Delete]
10	CarangMas	OKTOBER	2021	602	208400	11	625	[Add] [Delete]

Figure 8. Product Data

Figure 8 displays the menu used to input data from the previous month and year. By clicking add, the user can input product data, month, year, order, production costs, stock, and production. If everything has been input, you can immediately click save.

Figure 9, is a menu for predicting production quantities by inputting product data, month, year, order, production costs, and stock. If so, click the prediction button to see the results of predicting production quantities using the Tsukamoto method.

No	Produk	Bulan	Tahun	Permintaan	Biaya Produksi	Stok	Prediksi	Aktual	Aksi
1	CarangMas	AGUSTUS	2022	6750	21250000	0	6120	6000	[Add] [Delete]
2	CarangMas	SEPTEMBER	2022	5360	18000000	11	5680	5000	[Add] [Delete]
3	CarangMas	OKTOBER	2022	6000	20000000	10	6043	5125	[Add] [Delete]
4	CarangMas	NOVEMBER	2022	6400	19500000	0	6030	6100	[Add] [Delete]
5	CarangMas	DESEMBER	2022	5450	18200000	25	5841	5600	[Add] [Delete]

Figure 9. Results

This menu contains a display of the results of the prediction process that we carried out in the previous menu. We can enter actual data as a comparison of the predicted data so that in the future it can be used as a reference for the production process. Users can also download the resulting file by clicking the pdf button and the file will automatically be downloaded.

3.2 Testing

Testing is carried out in several ways. Following are the results of the tests carried out:

a. Testing Results Using MAPE

This test looks for errors in each sample and then adds up each error value, then divides it by the number of samples tested. Test data was taken from January 2021- December 2022.

The sum of each error value from January 2021 to December 2022 is 98.08582. To find out the mape value, it can be calculated by dividing 98.08582 by 24 (the number of samples tested) so you get a mape value of 4.0868 which is still classified as in the interpretation of accurate results.

b. Algorithm Testing

Algorithm testing uses the Big O Notation method, this test places more emphasis on the algorithm function of a tool, whether it has reached efficiency or not. This test is carried out on the results of reading tools on the Web that have appeared and passed the algorithm. Because the algorithm is located on the web. So testing this method for the algorithm can be seen in Figure 10.

```

// defuzzifikasi
$mu_rendah_order = $this->
>derajat_keanggotaan_rendah($uji['order'], $data['order']['min'],
$data['order']['max']);
$mu_tinggi_order = $this->
>derajat_keanggotaan_tinggi($uji['order'], $data['order']['min'],
$data['order']['max']);
$mu_rendah_biaya = $this->
>derajat_keanggotaan_rendah($uji['biaya'], $data['biaya']['min'],
$data['biaya']['max']);
$mu_tinggi_biaya = $this->
>derajat_keanggotaan_tinggi($uji['biaya'], $data['biaya']['min'],
$data['biaya']['max']);
$mu_rendah_stok = $this->
>derajat_keanggotaan_rendah($uji['stok'], $data['stok']['min'],
$data['stok']['max']);
$mu_tinggi_stok = $this->
>derajat_keanggotaan_tinggi($uji['stok'], $data['stok']['min'],
$data['stok']['max']);
// mesin inferensi
// R-1
$alpha_predikat1 = min($mu_rendah_order,
$mu_rendah_shipment, $mu_rendah_stok);
$z1 = $this->_sedikit($alpha_predikat1,
$data['produksi']['min'], $data['produksi']['max']);
// R-2
$alpha_predikat2 = min($mu_rendah_order,
$mu_rendah_shipment, $mu_tinggi_stok);
$z2 = $this->_sedikit($alpha_predikat2,
$data['produksi']['min'], $data['produksi']['max']);
// R-3
$alpha_predikat3 = min($mu_rendah_order,
$mu_tinggi_shipment, $mu_rendah_stok);
// R-4
$alpha_predikat4 = min($mu_rendah_order,
$mu_tinggi_shipment, $mu_tinggi_stok);
$z4 = $this->_sedikit($alpha_predikat4,
$data['produksi']['min'], $data['produksi']['max']);
// R-5
$alpha_predikat5 = min($mu_tinggi_order,
$mu_rendah_shipment, $mu_rendah_stok);
$z5 = $this->_banyak($alpha_predikat5,
$data['produksi']['min'], $data['produksi']['max']);
// R-6
$alpha_predikat6 = min($mu_tinggi_order,
$mu_rendah_shipment, $mu_tinggi_stok);
$z6 = $this->_sedikit($alpha_predikat6,
$data['produksi']['min'], $data['produksi']['max']);
// R-7
$alpha_predikat7 = min($mu_tinggi_order,
$mu_tinggi_shipment, $mu_rendah_stok);
$z7 = $this->_banyak($alpha_predikat7,
$data['produksi']['min'], $data['produksi']['max']);
// R-8
$alpha_predikat8 = min($mu_tinggi_order,
$mu_tinggi_shipment, $mu_tinggi_stok);
$z8 = $this->_banyak($alpha_predikat8,
$data['produksi']['min'], $data['produksi']['max']);
// defuzzifikasi
$z = round(((($alpha_predikat1 * $z1) + ($alpha_predikat2 *
$z2) + ($alpha_predikat3 * $z3) + ($alpha_predikat4 * $z4) +
($alpha_predikat5 * $z5) + ($alpha_predikat6 * $z6) +
($alpha_predikat7 * $z7) + ($alpha_predikat8 * $z8)) /
($alpha_predikat1 + $alpha_predikat2 + $alpha_predikat3 +
$alpha_predikat4 + $alpha_predikat5 + $alpha_predikat6 +
$alpha_predikat7 + $alpha_predikat8), 0);
return $z;

```

Figure 10. Algorithm Code

Based on the results above, the use of the fuzzy algorithm when tested using the Big O notation method produces $O(1)$ or can be said to be included in the Big O Notation Constant Time. Constant Time means that the amount of input given to an algorithm will not affect the processing time (runtime) of the algorithm.

4. CONCLUSION

The Carang Mas production quantity prediction website uses the Fuzzy Tsukamoto method at UD.ASTER which was created to be run and successfully provide decisions using three input variables, namely Demand, Stock, and Production Costs. The results of algorithm testing using Big O notation produce $O(1)$ or can be said to be included in Big O Notation Constant Time, which means that the amount of input given to an algorithm will not affect the processing time of the algorithm. Furthermore, in the MAPE test, it is known that comparing the actual results with the predicted results from January 2021 to December 2022, the values obtained are **4,0868**, where these results are quite accurate when seen from the MAPE interpretation table. So it can be useful as decision support in predicting production quantities.

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