APPLICATION OF MAMDANI FUZZY METHOD TO PREDICT THE AMOUNT OF PINE RESIN PRODUCTION

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ABSTRACT

PT. Inhutani IV Aceh District needs to plan the right production in order to achieve maximum profit. Therefore, the company needs to develop a system that can predict the amount of pine resin that can be produced. This study uses data from PT. Inhutani IV Aceh District is engaged in the production of raw pine resin. This study uses the mamdani fuzzy method to predict the amount of latex production based on demand, supply, and latex production data per month in 2019-2020. Based on the results of calculations that have been carried out, with the input variable demand in January 2021 of 91,404 kg and supply in December 2020 of 71,466 kg, with the fuzzy mamdani method, the prediction results of the pine resin that the company can produce is 191,763 kg in January 2021 and based on the results of calculations using the MAPE accuracy measure, the fuzzy mamdani method has a MAPE value of 45.69 % so it can be concluded that the mamdani fuzzy method is pretty good for predicting the production of pine resin at PT. Inhutani IV Aceh District.

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1. INTRODUCTION

Pine sap is a non-timber forest product with high economic value to be processed into gondorukem and turpentine [1]. Pine sap has many benefits that are used in health or industry. Pine tree sap has a therapeutic effect of reducing stress and helping relieve respiratory disorders, bronchitis, or other respiratory diseases such as sinus, colds, and shortness of breath by utilizing essential oils from pine as raw material for the pharmaceutical industry, soap-making, antiseptic, disinfectant, camphor, cosmetics, batik, plastic, printer ink, paint oil, solvent mixtures, and much more [2].

In Indonesia, there are several largest pine resin producing companies. Based on the results of the author's interview with PT. Inhutani IV Aceh District, some of these companies are Perum Perhutani to manage pine forests in Java, PT. Inhutani I, with its area in South Sulawesi, and PT. Inhutani IV with areas in West Sumatra, North Sumatra, and Aceh. PT. Inhutani IV Aceh District is located in Bener Meriah District/City, Central Aceh, and Gayo Lues. According to data from the [3], Aceh Province is in the top 10 provinces with the largest forests in Indonesia, with forest and water conservation areas in Aceh Province covering an area of 3,545,222 ha. Based on data from PT. Inhutani IV Aceh District in 2020, for the pine forest tapping area in Aceh, the company covers an area of 3,520 ha [2].

The activity of estimating the expected level of product demand for a product or several products in a certain period of time in the future is the definition of forecasting. However, there are methods that are very flexible and have tolerances on existing data. The method introduced by Ebrahim Mamdani in 1975 has the advantage that it is easier to understand and accept by many parties, namely the fuzzy mamdani method [4]. So, based on the above conditions, the author is very interested in conducting research entitled "Application of the Fuzzy Mamdani Method to Predict the Amount of Pine Gum Production (Case Study: Data on Supply and Demand for Pine Gum Production at PT. Inhutani IV Aceh District)". Based on the problem formulation above, the purpose of this study is to find out how the application of the Fuzzy Mamdani method in predicting the determination of amount of pine resin production and to find out how the prediction results in determining the amount of pine resin production [5].

2. RESEARCH METHODS

2.1 Population and Sample

The population in this study is data on demand, supply and production data of PT. Inhutani IV Aceh District. The sample in this study is data on the demand, supply, and production of pine resin per month for a period of two years (2019 - 2020).

2.2 Data Analysis Technique

In this study, the completion of the calculation process manually using the application of fuzzy logic mamdani method. Four stages must be done: determining the fuzzy set, applying the implication function, composition between rules, and confirmation (defuzzification). Next, perform calculations using the fuzzy inference system Matlab software mamdani method by inputting demand and supply data in the input column in the rule view. After that, to determine the accuracy of the predictions made, it will be measured using MAPE.

3. RESULTS AND DISCUSSION

3.1 Defuzzification

The results of the calculation of the defuzzification process for the demand variable of as much as 91,404 kg and supply of as much as 71,466 kg using the centroid method are as follows:

$$M_1 = \int\limits_{0}^{38.257} \mu(z)zdz = \int\limits_{0}^{38.257} (0,20)zdz = 146.359.804,9$$

$$M_2 = \int\limits_{38.257}^{95.857} \mu(z)zdz = \int\limits_{38.257}^{95.857} \left(\frac{z - 19.057}{96.000}\right) zdz = 2.097.111.270,7$$

$$M_3 = \int\limits_{95.857}^{329.526,6} \mu(z)zdz = \int\limits_{95.857}^{329.256,6} (0,80)zdz = 39.759.686.263,4$$

$$M_4 = \int\limits_{329.526,6}^{383.144} \mu(z)zdz = \int\limits_{329.526,6}^{383.144} \left(\frac{383.144 - z}{268.087}\right) zdz = 1.862.202.255,2$$

$$A_1 = \int\limits_{0}^{38.257} \mu(z)dz = \int\limits_{0}^{38.257} (0,20)dz = 7.651,4$$

$$A_2 = \int\limits_{38.257}^{95.857} \mu(z)dz = \int\limits_{38.257}^{95.857} \left(\frac{z - 19.057}{96.000}\right) dz = 28.800,5$$

$$A_3 = \int\limits_{95.857}^{329.526,6} \mu(z)dz = \int\limits_{95.857}^{329.526,6} (0,80)dz = 186.935,7$$

$$A_4 = \int\limits_{329.526,6}^{383.144} \mu(z)dz = \int\limits_{329.526,6}^{383.144} \left(\frac{383.144 - z}{268.087}\right) dz = 5.360,5$$

Description [6]:

M_i : Estimated value (estimation) of population parameters.

A_i : The value of the area of a clearly demarcated area (bounded by curves closed).

$\mu(z)$: Production area membership function.

$$Z^* = \frac{\int \mu(z)zdz}{\int \mu(z)dz} = \frac{M_1 + M_2 + M_3 + M_4}{A_1 + A_2 + A_3 + A_4} = \frac{43.865.359.594,2}{228.748,1} = 191.762,7$$

The calculation results of the defuzzification process with a demand variable value of 91,404 kg and a supply of 71,466 kg, so the pine resin that must be produced in January 2021 is 191,762.7 kg $\approx$ 191,763 kg. Meanwhile, the raw data shows the amount of pine resin produced in January 2021 at PT. Inhutani IV Aceh District as much as 206,365 kg.

From the above statement, it can be concluded that if it produces 191,763 kg in January 2021, PT. Inhutani IV Aceh District will produce optimally and will obtain maximum profit. The difference between raw data and mamdani fuzzy prediction is 14,602 kg.

3.2 MAPE Results Prediction Mamdani Method

After performing manual calculations as previously done to determine the accuracy of the predictions made, it will be measured using MAPE, the calculation can be obtained as follows:

Table 1. MAPE Calculation

No.	Month	Production (a_i)	Fuzzy $(\hat{a}_i)$	Error	$\left\|\dfrac{(a_i - \hat{a}_i)}{a_i} x\, 100\%\right\|$
1	Jan 2019	167.748	182.000	14.252	8,496
2	Feb 2019	149.785	185.000	35.215	23,510
3	Mar 2019	287.679	187.000	100.679	34,997
4	Apr 2019	248.751	158.000	90.751	36,483
5	Mei 2019	217.901	277.000	59.099	27,122
6	Jun 2019	81.065	173.000	91.935	113,409
7	Jul 2019	108.309	168.000	59.691	55,112
8	Agu 2019	189.421	183.000	6.421	3,390
9	Sep 2019	333.366	215.000	118.366	35,506
10	Okt 2019	325.342	184.000	141.342	43,444
11	Nov 2019	383.144	40.200	342.944	89,508
12	Des 2019	353.235	285.000	68.235	19,317
13	Jan 2020	150.226	45.300	104.926	69,845
14	Feb 2020	78.826	41.700	37.126	47,099
15	Mar 2020	121.805	221.000	99.195	81,438
16	Apr 2020	83.959	141.000	57.041	67,939
17	Mei 2020	54.314	42.600	11.714	21,567
18	Jun 2020	28.333	44.100	15.767	55,649
19	Jul 2020	28.827	45.500	16.673	57,838
20	Agu 2020	19.057	139.000	119.943	629,391
21	Sep 2020	29.601	175.000	145.399	491,196
22	Okt 2020	28.611	176.000	147.389	515,148
23	Nov 2020	48.469	178.000	129.531	267,245
24	Des 2020	90.595	172.000	81.405	89,856

Based on **Table 1**, it can be seen that there are 5 data that we cannot process because they have values above the formula limit (100%) namely data numbers 6, 20, 21, 22, and 23. Thus, only 19 samples can be used.

So:

$$MAPE = \frac{\sum_{i=1}^{n} \frac{a_i - \hat{a}_i}{a_i} \times 100\,\%}{n}$$

$$= \frac{868.117\,\%}{19}$$

$$= 45.69\,\%$$

Based on the test results regarding the calculation of production predictions with the application of Mamdani fuzzy logic using Matlab software, it can be seen from 19 data that meet the requirements with a percentage value of 45.69% because of MAPE value < 50 % then this forecasting method is quite good to use.

4. CONCLUSIONS

Based on the results of the description that has been stated previously, the results of the analysis of the application of fuzzy logic to predict the production of pine resin using the Mamdani method obtained the following conclusions:

1. For the prediction of pine resin production using the Mamdani fuzzy inference system method with 9 fuzzy rules, the MAPE value is 45.69%. This shows that the Mamdani method is quite good for predicting pine resin production.
2. Based on raw data on the amount of pine resin produced in January 2021 at PT. Inhutani IV Aceh District as much as 206,365 kg. While the number of predicted pine resin that can be produced by PT. Inhutani IV Aceh District with variable demand in January 2021 as much as 91,404 kg and supply in December 2020 as much as 71,466 kg with the fuzzy mamdani method obtained as much as 191,763 kg to meet consumer demand in January 2021. From this statement, it can be concluded that if it produces 191,763 kg in January 2021 PT. Inhutani IV Aceh District will produce optimally and will obtain maximum profit.

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