Implementation Fuzzy Logic in System Design for Predicting the Production of Songkets in West Sumatera

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Abstract. Fuzzy logic is widely applied in various fields, such as industry, communications, etc. Fuzzy logic was developed to solve an obscure problem. The problem that arises in the production at UMKM Songket Silungkang and Songket Pandai Sikek at this time is that there is no system used as a reference in predict the amount of production that will come. Where this method can utilize demand and supply data in the past which is then processed with fuzzy stages so as to produce production figures. The government has prioritized the development of the Silungkang songket handicraft business, which is a regional specialty, in order to enter the export market. In the early stages, the priority of the regional government was to increase the production of craftsmen by facilitating coaching for micro, small and medium enterprises (MSMEs), especially those engaged in songket crafts, to continue to be developed by increasing quality and creativity. By applying the Fuzzy Inference System method in predicting the production of Songket Silungkang Kota Sawahlunto and Songket Pandai Sikek, Agam City can help several parties such as the government, micro, small and medium enterprises in making efforts to handle and make good decisions towards increasing the production of Songket UMKM in each region. and can provide a comparison of the predicted results of production for the coming period so that it can produce the optimal number of songket based on market demand.

1. Introduction

The development of the small and medium industrial sector which has cooperative advantages The development of the small and medium industrial sector which has cooperative advantages in an effort to improve people's welfare is not as easy as it is said, in fact the development of the small and medium industrial sector is always faced with the same problem, namely lack of production. One type of small and medium industry that is currently experiencing development is the traditional songket craft industry. Even though it is not as famous as batik which has been declared the national dress of Indonesia, the popularity of the songket cloth has been expanding especially since the last three years. One of the songket-producing provinces in Indonesia is West Sumatra which is centered on two regions, namely Pandai Sikek and Silungkang.

This research was conducted in order to predict the production at UMKM Songket Silungkang and Pandai Sikek. There are several factors that can be considered in determining the amount of production, namely supply and demand. From the problem of optimizing the amount of

production, many methods and techniques are used. The method most often used is strict set logic. However, strict set logic cannot be operated or used by the general public, because besides being a bit complicated in calculation, constraints in production will also make it difficult to solve the problem of optimizing the amount of production. Apart from strict set logic, fuzzy logic can also be used in the problem of optimizing production. Methods that can be used in applying fuzzy logic to the production of goods in companies include the Mamdani method, the Tsukamoto method, and the Sugeno method (Salikin, Fajar. 2011).

In optimizing production, another factor that must be considered is inventory, where inventory is one of the problems that decision makers always face. Supply is needed because basically the demand pattern is irregular. Inventories are carried out to ensure certainty that when needed these products are available (Sunyoto, 2015).

From previous research (Rima, Gema Liana 2018), which only discusses the prediction of silungkang songket production, which every month the production goes well and is always stable. Therefore, the researcher wants to compare the prediction results with other types of songket, namely Songket Pandai Sikek. With the aim, we can see the public interest in this local work which is very global. The government prioritizes the development of songket handicraft businesses, one of which is Silungkang songket and Songket Pandai Sikek, which are regional specialties, in order to enter the export market. The export potential of Silungkang songket and Songket Pandai Sikek is very large, considering that these handicrafts are quite in demand abroad, especially Malaysia. In the early stages, the priority of the regional government was to increase the production of craftsmen by facilitating guidance for micro, small and medium enterprises (MSMEs), especially those engaged in songket crafts, to continue to be developed by improving quality and creativity.

Starting from this problem, it can be seen from previous research, namely that a dashboard application was built to determine the priority of PT Telkom technicians using fuzzy logic (Ali Hamsar, 2016). In this research (Indrabayu, 2012) discusses predicting rainfall with fuzzy logic. Where will the matching process and data class be carried out. The prediction results show an accuracy of 82.19%. The target data is adjusted into 5 categories, namely sunny, light rain, moderate rain, heavy rain and storm based on BMKG standards. Whereas in this study, the Fuzzy Inference System with the Tsukamoto Method can predict the Professional Competence Level of Educators by including components or scores of professional competence of educators (Tito Pinandita, 2012).

Fuzzy logic is believed to be very flexible and tolerant of existing data (Supardi, 2012). By using fuzzy logic, it is hoped that a model of a system that is capable of predicting and predicting the amount of production at Songket Silungkang MSMEs and Songket Pandai Sikek will be produced. Fuzzy logic is a methodology of "counting" with linguistic variables, instead of counting with numbers. The words used in fuzzy logic are not number-specific, but they are much closer to human intuition. Humans can immediately "feel" the value of the variable words they use daily, Indrabayu (2012).

According to Supardi (2012), fuzzy logic is a set theory, the mathematical concepts that underlie fuzzy reasoning are quite easy to understand. In addition, fuzzy logic is very flexible, meaning that it is able to adapt to changes and uncertainties that accompany problems. Fuzzy logic is applied to the category classification of each variable. So that it is possible to find differences in results during the calculation process.

In the comparative analysis research of production predictions using fuzzy logic, there are several methods used but the mamdani fuzzy inference system will be chosen to solve this problem.

By applying the fuzzy inference system method in analyzing the comparative predictions of the production of Songket Silungkang Kota Sawahlunto and Songket Pandai Siket Kota Agam, this can help several parties such as the government, micro, small and medium enterprises in making efforts to handle and make good decisions on increasing production respectively UMKM Songket.

2.Methodology

In this study, collecting data in the form of production, demand and supply , describes research work information (ERY Sahulata, 2020) . The research begins by identifying the problem, namely using the mamdani fuzzy inference system method which helps determine the prediction criteria for the production of Songket Silungkang and Pandai Sikek which are needed by determining the demand and supply.

The research objective is to determine the prediction of the production results of each UMKM Songket by applying the mamdani fuzzy inference system and testing a prediction method that can describe how the production is every month so that it can be measured the extent of people's interest in traditional works such as songket using Fuzzy Mamdani.

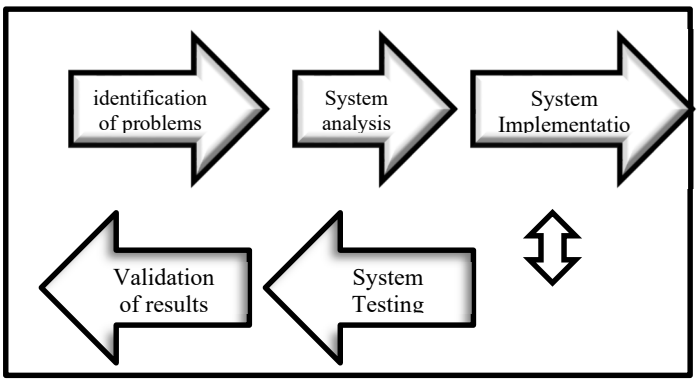

Figure 1. Research Framework

3. Results and discussion

This section describes the description of research work. This research begins by identifying the problem, namely using the *mamdani fuzzy inference system method* which helps determine the prediction criteria for the production of Songket Silungkang and Pandai Sikek which are needed by determining the demand and supply.

The research objective is to determine the prediction of the production results of each UMKM Songket by applying the mamdani *fuzzy inference system* and testing a prediction method that can describe how the production is every month so that it can be measured the extent of people's interest in traditional works such as songket using *Fuzzy Mamdani* . In the next stage, data collection was carried out by direct *observation*.

Table 1. Random Data on Demand, Inventory and Production

Month	UMKM Silungkang			UMKM Pandai Sikek		
	Stock (sheet)	Request (sheet)	Production (sheet)	Stock (sheet)	Request (sheet)	Production (sheet)
Jan 2016	176	61	186	95	40	70
Feb 2016	155	71	198	70	34	40
Mar 2016	176	38	157	76	55	57
•	•	•	•	•	•	•
•	•	•	•	•	•	•
•	•	•	•	•	•	•
Sept 2018	193	45	212	125	40	50
Oct 2018	137	64	193	27	50	75
Nov 2018	116	40	135	26	45	65

3.1 Fuzzyfication

There are 2 main variables for input and 1 variable for output to determine the amount of production . demand 1, input supply 2 and as output, namely production as seen in table 2 .

Table 2. Discussion Universe

Function	Variable	The Universe of Silungkang Songket Talks (Strands)	The Universe Clever Sikek Songket Talk (Strands)
Input	Request	2 0 - 80	15-70
	Stock	50 - 210	25 - 125
Output	Production	8 0 - 2 2 0	20-100

1. Analysis for Demand Variabel

The demand variable is stated in a down, medium and rising condition. Where each has a predetermined value range from the Silungkang UMKM. The specified value ranges from the lowest value of 20 strands to the highest value of 80 strands and from the MSME Pandai Sikek side, the values range from the lowest value of 15 to the highest value of 70 strands. The fuzzy set for input 1 is shown in table 3.

Table 3. *Fuzzy Sets* for Input 1

Variable	MF model	Set Variables	Range Silungkang	Range Pandai Sikek
Request	Trapmf	Down	20 - 55	15 - 50
	Trimf	Medium	4 0 - 75	35 - 70
	Trapmf	Ride	55 - 90	50 - 85

2. Analysis for Supplies Variabel

Inventory variables have a few, medium and many conditions. Each condition has a predetermined value range from the UMKM Silungkang and SME Clever Sikek. The range of values for the songket silungkang specified was from the lowest value of 50 strands to the highest value of 210 strands while the Songket Pandai Sikek set the lowest value of 25 to the highest value of 100 strands.The fuzzy set for input 2 is shown in Table 4.

Table 4. The set *Fuzzy* For Input 2

Variable	MF model	Set Variables	Silungkang Range	Pandai Sikek Range
Stock	Trapmf	a little	50 - 145	25 - 75
	Trimf	Medium	100 - 195	50 - 100
	Trapmf	Lots	145 - 230	75 - 125

3. The degree of membership function of production variables

The production variable has a condition that is decreasing, increasing. Each condition ranges from the lowest value of 80 strands to the highest value of 220 strands for Songket

Silungkang. And the lowest value of 20 strands to the highest value of 100 strands for Songket Pandai Sikek. The fuzzy set for the output is shown in Table 5.

Table 5. Fuzzy Production Set for Output

Variable	MF model	Set Variables	Range Silungkang	Range Pandai Sikek
Production	Trimf	Less	80 - 130	20 - 50
	Trimf	Medium	131 - 180	51 - 80
	Trimf	Increased	181 - 2 30	81 - 110

3.2 Rules

After forming the variable membership function, the fuzzy logic rules are obtained. Based on the data obtained, the rules that can be formed are as follows:

Table 6. Rule

Variabel		
Input		**Output**
Request	**Stock**	**Production**
Less	Less	Less
Less	Medium	Less
Less	Increased	Less
Medium	Less	Increased
Medium	Medium	Medium
Medium	Increased	Medium
Increased	Less	Increased
Increased	Medium	Increased
Increased	Increased	Increased

3.3 Fuzzy Logic Calculation

a. Silungkang Songket

Total demand for goods on UMKM Silungkang to the next is 43 strands and inventory is 180 , then the number of songket Silungkang to be produced will be sought with Mamdani Fuzzy calculation process. The calculation process will be described below

1. Fuzzyfication

   There are 3 *fuzzy* variables being modeled:

   a. Demand consists of Increase and Decrease

   μ Decreased [43] = (55- 43) / (55– 2 0)
   = 12/35
   = 0 , 34

   μ Medium [43] = (43- 40) / (55– 40)
   = 3/ 15
   = 0 , 2

   μ Up [43] = Does Not Enter Range

   b. Inventory consists of Little and Increasing

   μLittle [180] = 0

   μ Medium [180] = (195 - 1 8 0) / (19 5 - 1 45)
   = 1 5/5 0
   = 0.3

   μ Increase [180] = (230 - 1 8 0) / (230 - 1 45)
   = 50 / 85
   = 0.58

2. Rule
   At this stage, the formation of fuzzy rules is formed from two input variables and one output variable, by analyzing the data against the boundaries of each fuzzy set of input and output variables. Then we get 9 fuzzy rules that are used.

3. Machine Inference (Function Min)

[R1] = IF Demand is less and inventory is less THEN Production of goods is reduced
α-predicate $_1$ = μ Decrease ∩ Slightly
= min (μLess, μ Slight)
= min (0.3; Not in range)
= 0

[R2] = IF Demand is LESS and Inventory is DOWN THEN Production of goods is LESS
α-predicate $_2$ = μ Decreased ∩ Medium
= min (μLess, μ Medium)
= min (0.3 ; 0.3)
= 0 , 3

[R3] = IF Demand is reduced and Inventory increases THEN Production of goods is reduced
α-predicate $_3$ = μ Decreases ∩ Increases
= min (μ Decreases , μ Increases)
= min (0, 3 ; 0.5)
= 0, 3

[R4] = IF Demand is Medium and Inventory is LITTLE THEN Production of goods is increasing
α-predicate $_3$ = μ Medium ∩ Slightly
= min (μ medium , μ little)
= Min (0. 2 ; Not In Range)
= 0

[R5] = IF Demand is MEDIUM AND Inventory IS MEDIUM THEN Production of goods is medium
α-predicate $_4$ = μ Medium ∩ Medium
= min (μ Medium , μ Medium
= Min (0. 2 ; **0.3**)
= 0. 2

[R6] = IF MEDIUM Demand And Inventory INCREASES THEN MEDIUM Production
α-predicate $_4$ = μ Medium ∩ Increasing
= min (μ Medium , μ Increasing)
= Min (0. 2 ; 0 , 5)
= 0 .2

[R7] = IF Demand increases and inventory is LITTLE THEN Production of goods increases
α-predicate $_4$ = μIncreased ∩ Slightly
= min (μ Up, μS little)
= min (not in range ; 0 , 5)
= 0

[R8] = IF Demand is increasing and supply is currently increasing production of goods is increasing
α-predicate $_4$ = μ Increasing Medium
= min (μ Up, μ Medium)
= min (Not in Range; 0 , 2)
= 0

[R9] = IF Demand increases and supply increases THEN Production of goods increases
α-predicate $_4$ = μ Increasing ∩ Increasing
= min (μ Up , μ Increase)

= min (Not in Range ; 0 , 5)
= 0

4. Defuzzyfication

The final step in this process is *defuzzyfication* or also known as the affirmation stage . *The* method used is the *centroid* method . The following converts *fuzzy* sets to real numbers :

[Rule 02] µProduction of Silungkang Songket is reduced (x) = 0,3 , then the value of x is;
Production (*reduced*)
= 180 - *x / 180 - 130* = 0.3
= (180 - (0,3 x 50)
= 180 - 15
= 165
[Rule 03] µ Reduced Silungkang Songket Production (x) = 0,3 then the value of x is;
Production (*reduced*)
= 180 - *x / 180 - 130* = 0.3
= (180 - (0,3 x 50)
= 180 - 15
= 165
[Rule 05] µMedium Silungkang Songket Production (x) = 0,2 then the value of x is;
Production (Medium)
= (d - 130) / 180 - 130 = 0,2
= (d - 130) / 50 = 0,2
= (0.2 x 50) + 130
= 140
[Rule 06] µMedium Silungkang Songket Production (x) = 0,2 then the value of x is;
Production (Medium)
= (d - 130) / 180 - 130 = 0, 2
= (d - 130) / 50 = 0 , 2
= (0.2 x 50) + 130
= 140

So, by using the *defuzzy weighted average* method , the production value of songket silungkang is obtained :

$$Z1 = (0,3 * 165) + (0,3 * 165) + (0,2 * 140) + (0,2 * 140)$$
$$= 0,3 + 0,3 + 0,2 + 0,2$$
$$= \frac{49 , 5 + 49.5 + 28 + 28}{1}$$
$$= \frac{155}{1}$$
$$= 155 \text{ Strands (Medium)}$$

Thus, the prediction obtained seBertambah production of **155** strands, that are in the range 130-180 is Medium.

b. Pandai Sikek

The total demand for goods at UMKM Pandai Sikek for the next is 40 pieces and the supply is 90 , then the number of Songket Pandai Sikek to be produced will be searched by the Fuzzy Mamdani calculation process. The calculation process will be described below.

1. Fuzzyfication

There are 3 *fuzzy* variables being modeled:

a. Demand consists of increase and decrease

μDecreased[40] = (50- 40) / (50– 15)
= 10 / 35
= 0,28

μMedium [40] = (40- 35) / (50– 35)
= 5 / 15
= 0,33

μUp[40] = Does Not Enter Range

b. Inventory consists of Little and Increasing

μlittle [90] = 0

μmedium[90] = (100- 90) / (100 - 75)
= 10 / 25
= 0,4

μincrease[90] = (125- 90) / (125 - 75)
= 35 /50
= 0,7

c. Rule

At this stage, the formation of fuzzy rules is formed from two input variables and one output variable, by analyzing the data against the boundaries of each fuzzy set of input and output variables. Then we get 9 fuzzy rules that are used

d. Inference Engine (Min Function)

[R1] = IF Demand is less and inventory is less THEN Production of goods is reduced

α-predicate $_1$ = μ Decrease ∩ Slightly
= min (μLess, μ Slight)
= min (0,28 ; 0)
= 0

[R2] = IF Demand is LESS and Inventory is MEDIUM THEN Production of goods is LESS

α-predicate $_2$ = μ Decreased ∩ Medium
= min (μLess, μ Medium)
= min (0,28 ; 0,4)
= 0,28

[R3] = IF Demand is reduced and Inventory increases THEN Production of goods is reduced

α-predicate $_3$ = μ Decreases ∩ Increases
= min (μ Decreases , μ Increases)
= min (0,28 ; 0,7)
= 0,28

[R4] = IF Demand is Medium and Inventory is LITTLE THEN Production of goods is increasing

α-predicate $_3$ = μ Medium ∩ Slightly
= min (μ medium , μ little)
= Min (0,33 ; 0)
= 0

[R5] = IF Demand is MEDIUM AND Inventory IS MEDIUM THEN Production of goods is medium

α-predicate $_4$ = μ Medium ∩ Medium
= min (μ Medium , μMedium)
= Min (0,33 ; **0,4**)
= 0,33

[R6] = IF Demand is Medium And Inventory Increases Then Production Is Medium
α-predicate $_4$ = μ Medium ∩ Increasing
= min (μ Medium, μ Increasing)
= Min (0,3 ; 0,7)
= 0,33
[R7] = IF Demand is increases and inventory is LITTLE THEN Production of goods increases
α-predicate $_4$ = μIncreased ∩ Slightly
= min (μ Up, μS little)
= min (0 ; 0)
= 0
[R8] = IF Demand is increasing and supply is currently increasing production of goods is increasing
α-predicate $_4$ = μ Increasing ∩ Medium
= min (μ Up, μMedium)
= min (0; 0,4)
= 0
[R9] = IF Demand increases and supply increases THEN Production of goods increases
α-predicate $_4$ = μ Increasing ∩ Increasing
= min (μ Up , μ Increase)
= min (0 ; 0 , 7)
= 0

e. Defuzzyfication

The final step in this process is *defuzzyfication* or also known as the affirmation stage . *The* method used is the *centroid* method . The following converts *fuzzy* sets to real numbers :

[Rule 02] μProduction of Silungkang Songket is reduced (x) = 0,28 , then the value of x is;
Production (*reduced*)
= 80 - *x / 80 - 50* = 0,28
= (80 - (0,28 x 30)
= 80 - 8,4
= 71,6
[Rule 03] μProduction of Silungkang Songket is reduced (x) = 0,28 , then the value of x is;
Production (*reduced*)
= 80 - *x / 80 -50* = 0,28
= (80 - (0,28 x 30))
= 80 - 8,4
= 71 , 6
[Rule 05] μMedium Silungkang Songket Production (x) = 0.33 , then the value of x is;
Production (Medium) = (D - 50) / 80-50 = 0,33
= (d - 50) / 30 = 0,33
= (0,33 x 30) + 50
= 60
[Rule 06] μMedium Silungkang Songket Production (x) = 0,33 , then the value of x is;
Production (Medium) = (D - 50) / 80-50 = 0, 33
= (d - 50) / 30 = 0,33
= (0,33 x 30) +50
= 60

Thus, using the method *defuzzy weighted average* values obtained production Pandai Sikek songket are :

Z1 = (0,28 * 74) + (0,28 * 74) + (0,33 * 60) + (0,33 * 60)
= 0,28 + 0,28 + 0,33 + 0,33

$$= \frac{20{,}72 + 20{,}72 + 19{,}8 + 19{,}8}{1{,}22}$$

$$= \frac{81{,}04}{1{,}22}$$

$$= 66{,}42$$

= 66 Strands (Medium)

So the production predictions obtained Average **66** strands, is in the range of 51 - 80 is Medium .

For the two production results between the production of UMKM Songket Silungkang and Pandai Sikek, it can be concluded that the results are the same with different production quantities but in the same range, namely "Medium ".

Next, we do a system design in determining the production of songket includes several stages, the first is identifying the functional requirements in preparing the implementation design which aims to design and design the system **.**

The embodiment of the design that we have created using the PHP programming language and database, as well as implementing the Mamadani method into the system. The next stage , testing the software that has been produced. Tests are carried out to ensure that the application made is in accordance with the design and all functions can be used properly .

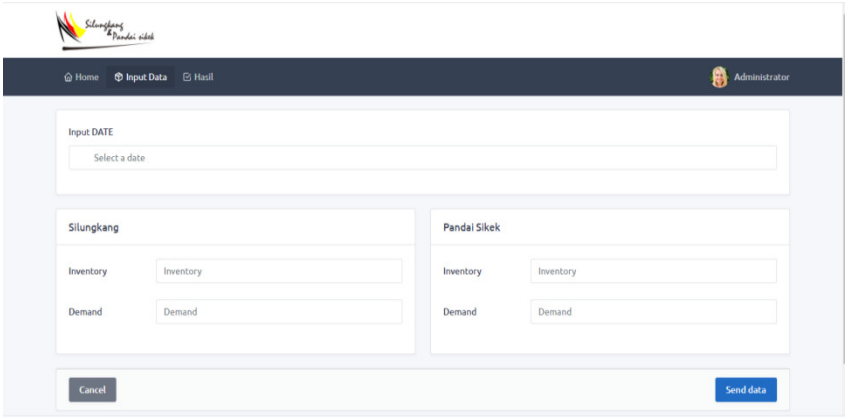

Figure 1. Songket production determination system

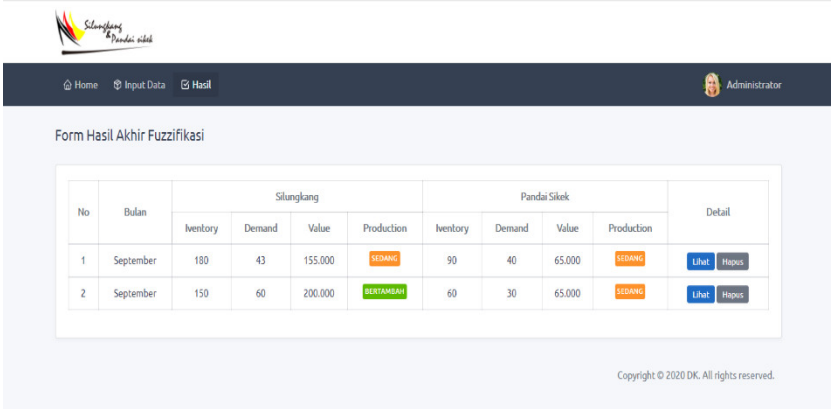

Figure 2. Fuzzyfication Result System

From manual data search and comparison with the system, the results are the same. In figure 9, it can be seen that 43 pieces of Silungkang Songket demand and 180 supplies obtained a production of 155 sheets in the medium range. Meanwhile, 40 pieces of Pandai Sikek Songket and an inventory of 90 resulted in a production of 65 sheets in the medium range.

It can be concluded, that manual search and search that are applied to the system are not much different. Therefore, this system is expected to be used to make it easier to predict songket production.

4. Conclusion

a. By using this system UMKM Songket Silungkang and Songket Pandai Sikek, West Sumatra can know the production / sales of songket that will be produced in the future. because this system successfully predicts songket production. Which production becomes a picture for MSMEs in making decisions. This can be done through the process of selecting data / information found in the form of supply data and demand data which are used as factors / inputs in producing output, namely predicting songket production.
b. The use of this application is easier and faster to predict the production of Silungkang and Pandai Sikek songket. This can be done by filling in the supply and demand data into the system and the system will process the required data and will produce output, namely production decisions quickly.
c. This application aims so that UMKm Songket Silungkang and Clever Sikek can maintain the amount of production to be better and more effective

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