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Fuzzy Logic for Determination of Community Assistance Using the Tsukamoto Method for Residents of Kasreman Village, Rembang

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Abstract - The obstacle to regional progress and the main cause of social problems is due to the large number of poor people, so there must be a poverty management program by the government, one of which is citizen assistance. The selection process by the local village apparatus is very much needed in the process of determining the recipients of citizen assistance, because the quota for the recipients of citizen assistance is less than that of registrants for citizen assistance. The distribution of aid does not fall to the right party resulting in injustice to other underprivileged families so that it creates several problems, where the method that will be used is Tsukamoto's Fuzzy Logic. In this study, the data used are land area, income of residents, number of dependents of the family. The evaluation method carried out in this study is using a confusion matrix, for one test the level of accuracy produced is 92.74%. Based on the experiment, it can be concluded that the Tsukamoto algorithm is quite accurate in determining citizen assistance to the residents of Kasreman Village, Rembang.

Keywords - Determination of Community Assistance, the Tsukamoto Method

1. INTRODUCTION

One indicator of development success is economic growth, poverty reduction that can be achieved is the goal of a development. The obstacle to regional progress and the main cause of social problems is due to the large number of poor people. So that there must be a poverty management program by the government, one of which is citizen assistance. Strategic and comprehensive steps are needed to meet the basic needs of citizens. The selection process by the local village apparatus is very much needed in the process of determining the recipients of citizen assistance, because the quota for recipients of citizen assistance is less than that of registrants for citizen assistance. The distribution of aid does not fall to the right party, resulting in injustice to other underprivileged families, causing several problems. The various criteria used and also have different value ranges causing the expected results of the selection process to not match the reality [1]–[3]. In practice in the field, there is no reference to the criteria that have been determined in making decisions to determine the recipients of citizen assistance that has occurred so that it results in an element of subjectivity. Along with the above, that more and more data will be processed in the selection process.

A decision support system is a system that helps decision makers by completing information from data that has been processed relevantly and needed to make decisions about a problem more quickly and accurately. Decision making of a problem, whether it is a simple or complex problem, requires comprehensive and accurate information, the ability to analyze and process information as well as the right method of solving it [4]–[7]. allows for more objective decision making. Currently, the system has been applied in various fields, for example in determining employee admissions, determining student scholarships and others.

Based on the existing information, it will be able to determine the right attitude and decision making towards a problem at hand, one of the important issues related to this information is the information system to select prospective beneficiaries of citizen assistance residing in an area. So far, the village apparatus has only selected a few residents who were recommended by other members of the village apparatus to become potential recipients of community assistance [8]. In terms of objectivity this is not effective. With the design of a computerized decision support system that can reduce subjectivity in decision making and can speed up the data collection process.

By combining data and knowledge to increase effectiveness in the decision-making process, it is hoped that later it will be able to assist decision-makers in deciding the best alternatives in determining the right target for receiving citizen assistance. In this study, we will focus on a village in Rembang Regency, precisely in Kasreman Village, Rembang District, Rembang Regency. Kasreman village is an area with a fairly high poverty rate, so the local village officials try to rack their brains to predict and select eligible residents and are entitled to receive citizen assistance. In reality, the implementation of the citizen assistance program still experiences many pros and cons within the community. The problem that most often occurs is that it is not right on target, there are still poor people who do not get assistance but well-off residents who have houses, fields and vehicles and savings instead get assistance. because of this, there were pros and cons and even demonstrations regarding citizen assistance programs that were not well targeted [3], [9], [10].

Fuzzy logic is a problem-solving control system methodology, which is suitable to be implemented on systems, ranging from simple systems, small systems, embedded systems, PC networks, multi-channel or workstation-based data acquisition, and control systems. (Aldyanto & Aldyanto, 2016) To map an input space into an output space is the right way in this logic, its flexible nature so that it can build and apply the experiences of decision makers directly without having to go through a training process. Thus, it is assumed that the Fuzzyy Tsukamoto method can also be used to predict the feasibility of receiving citizen assistance. Based on the problems above, the research title will be raised "Fuzzy Logic for Determination of Community Assistance Using the Tsukamoto Method for Residents of Kasreman Village, Rembang".

2. RESEARCH METHOD

2.1. State of The Art

The following are related research journals used in conducting research as shown in Table 1. Based on the relevant research references above, fuzzy logic is very suitable for decision making, so research is focused on implementing the Tsukamoto fuzzy algorithm which is used for decision making to predict beneficiaries by processing the required attributes, and it is expected to provide information on providing assistance to the population evenly.

Table 1. State of The Art

No	Information		
	Author	Method	Result
1	Laras Purwati Ayuningtias, Mohamad Irfan, Jumadi [4]	Fuzzy logic using tsukamoto, sugeno, and mamdani	In this study, the fuzzy logic algorithm of the Tsukamoto method is very suitable for determining predictions or estimating the number of new student registrant data at the Faculty of Science and Technology at the State Islamic University of Sunan Gunung Djati, Bandung in the future when compared to the other two fuzzy logic methods.
2	Dwi Marisa Efendi, Ferly Ardhy [11]	Fuzzy logic	Based on the prediction test using this fuzzy logic method, the Tsukamoto method is found as the most superior method in predicting the amount of production, where it is known that the prediction results with the company's production results are not much different, which can be seen from the error value obtained by 1%.
3	Evi Nur Azizah, Imam Cholissodin, Wayan Firdaus Mahmudy [3]	Fuzzy tsukamoto using genetic algorithm	The results of the system evaluation value using mape calculations produce an average error of 0.1369 with a Fitness value of 0.8796. The results of this evaluation value prove that the determination of housing prices using fuzzy tsukamoto and genetic algorithms is able to produce optimal final results.

2.2. Fuzzy Logic

Artificial intelligence is one of the fields of computer science that utilizes computers so that they can behave intelligently like humans. Computer science develops software and hardware to imitate human actions [1]–[3], [12], [13]. Human activities are imitated such as reasoning, vision, learning, problem solving, natural language discussion and so on. Expert systems, computer games (games), fuzzy logic, artificial neural networks and robotics are some of the fields used in artificial intelligence.

Fuzzy Logic is a precise way to map an input space into an output space. (Pranata, et al., 2017) Fuzzy logic is based on the uncertainty of the boundary between one criterion and other criteria due to the cumulative human judgment of something. For example, the expression of good clothes, hot air, and so on often creates uncertainty between one criterion and another. The fuzzy set concept is the basis of the fuzzy logic system. The fuzzy set maps the qualitative criteria to the membership function [14], [15]. Thus, each qualitative criterion in the fuzzy set has a membership function. The membership function of the qualitative criteria in the fuzzy set has a value between 0.0 to 1.0 so that it is more balanced in the an-operation which is limited by a certain factor. The membership function is a curve that shows the mapping of input data points into their membership values. Fuzzy logic has several advantages, namely as follows.

1. Its usability is considered to be better than the existing control techniques.
2. Famous reliability in fuzzy controller.
3. Easy to repair.
4. Provides excellent control over other techniques in fuzzy control.
5. Only need funds and small businesses.

Following are the disadvantages of Fuzzy Logic algorithm:

1. Technically, engineers and scientists in the past and now have experience and control tools that exist in using technology, but many of them are not familiar with fuzzy control theory.
2. There are not many courses/education centers and textbooks that reach every level of education (undergraduate, postgraduate, and onsite training) not many have explored textbooks and coursework/education centers.
3. In the use of fuzzy controllers regarding methodologies for solving control problems, there is no standardized and uniform systematic knowledge until now.
4. There is no general method for implementing and developing fuzzy controllers.

2.3. Fuzzy Inference System

Fuzzy Inference System also called Fuzzy Interface engine (FIS) [16] is a system that can reason with similar principles as humans do reasoning with their instincts. In general, there are three methods of fuzzy logic, namely, the Mamdani method, the Tsukamoto method, and the Takagi Sugeno method. The method used in this study is the Tsukamoto method. The 3 units used in the inference system are as follows:

1. The image containing the input text is a collection of fuzzy rules in the form of an IF THEN statement. Fuzzyfication is a process to change the input system that has anometric value into a linguistic variable by means of which existing membership functions will be stored in the fuzzy knowledge base.
2. Inference engine, which is the process of converting a fuzzy input into a fuzzy output that will follow the rules (IF-THEN Rules) set on the fuzzy knowledge base.
3. Defuzzyfication to change an output fuzzy from an inference engine so that it produces a firm value when performing fuzzification.

2.4. Fuzzy Tsukamoto

The Tsukamoto method is an extension of monotonous reasoning. In the Tsukamoto method, every consequence of the IF-THEN rule must be represented by a fuzzy set with a monotonous membership function. In using the fuzzy Tsukamotoo method [5], [8], the first step is to determine the membership functions, then determine the rules and then the categories will be clustered into each group according to the rules applied. The following are the steps of the Tsukamoto Method as follows:

1. Fuzzyfication

   Changing the input of a system that has a value of affirmation into a linguistic variable (fuzzification). In fuzzyfication, the input variable (crisp) of the fuzzy system b is transferred to the fuzzy set of b fuzzy i so that b can be used in calculations.

   The value of b membership b of an item x in a set bA, has 2 possibilities:

   1, x member A

   0, not a member of A

   Example:

   S = [1,2,3,4,5,6]; A = [1,2,3]; B = [3,4,5]

   Membership value 2 on A = μA[2] = 1

   Membership value 2 on A = μA[4] = 0

   Membership value 2 on B = μB[5] = 1

   Fuzzy set, the degree / value of membership lies in the range 0 to 1 so that:

   - If x has a degree of fuzzy membership A [x] = 0 → b x is not a member of the set A
   - If x has a degree of fuzzy membership A [x] = 1 → x is a full member of the set A

   a. Membership function

      A curve that shows the mapping of data input points into the value/degree of membership which has an interval between 0 to 1.

      - Sigmoid function

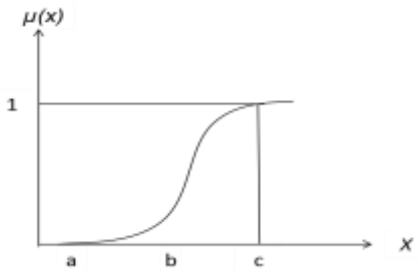


Figure 1. Sigmoid Function

Where :

$$Sigmoid(x,a,b,c)=\begin{cases}0, x\le a\\ 2\{((x-a)/(c-a)\}^2, a<x\le b\\ 1-2\{((x-c)/(c-a)\}^2, b<x\le c\\ 1, c<x\end{cases} \quad (1)$$

- Phi function

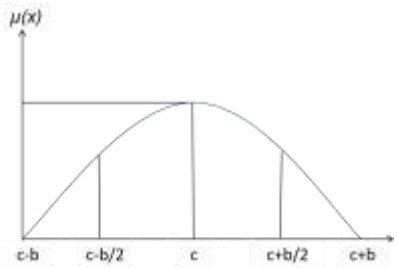


Figure 2. Phi Function

Where :

$$phi(x,b,c)=\begin{cases}phi(x,c-b,c-\frac{b}{2},c), x\le c\\ 1-phi(x,c,c+\frac{b}{2},c+b), x>c\end{cases} \quad (2)$$

- Triangular function

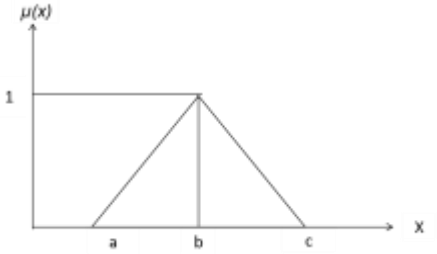


Figure 3. Triangular Function

Where :

$$Triangular(x,a,b,c)=\begin{cases}0, x\le a, x\ge c\\ (x-a)/(b-a), a<x\le b\\ -(x-c)/(c-b), b<x\le c\end{cases} \quad (3)$$

- Trapezoid function

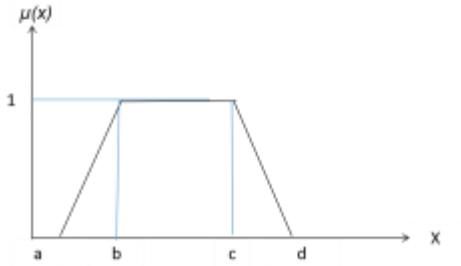


Figure 4. Trapezoid Function

Where :

$$Trapezium(x,a,b,c,d) = \begin{cases} 0, x \le a, x \ge d \\ (x-a)/(b-a), a < x \le b \\ 1, b < x \le c \\ -(x-d)/(d-c), c < x \le d \end{cases} \quad (4)$$

- Basic Operations of Fuzzy Sets
  Used to combine and modify fuzzy sets. The membership value as a result of the set operation is called α predicate.

Table 2. Basic Operations of Fuzzy Sets

Operator	Operasi	Fungsi Keanggotaan
AND	Intersection	μ(A∩B)(x) = min[μ(A(x),μB(x)]
OR	Union	μ(A∪B)(x) = max[μ(A(x),μB(x)]
NOT	Complement	μAc(x) = 1-μA(x)

2. Formation of Fuzzy Rule knowledge base in the form (IF…THEN)
   - A fuzzy IF-THEN rule is an IF-THEN statement where some of the words in the statement are defined as membership functions.
   - A fuzzy production rule is a fuzzy relation between two fuzzy propositions. The rule is expressed in the form: IF (fuzzy proposition 1 → antecedent) THEN (fuzzy proposition 2 → consequent)
   - The premise of a fuzzy rule can have more than one part (premise1, premise2, i…etc), all parts of the premise are calculated simultaneously and solved for a single value by using fuzzy operators in fuzzy sets.
     - IF premise 1 AND premise 2 THEN conclusion 1 AND conclusion 2
     - Where AND is a fuzzy operator
     - Premise1 and premise2 are input variables
     - Conclusion 1 and conclusion 2 are output variables

3. Inference engine
   Using MIN implication to get -predicate value for each rule (α1, 2, 3, .., αn). Then each -predicate value is used to calculate the crisp inference output for each rule (z1, z2, z3, .., zn) as shown in equation (5) and (6).

$$Z = \begin{cases} 1, & z \le 0 \\ (50-z)/50-0), & 0 \le z \le 50 \\ 0, & z \ge 50 \end{cases} \quad (5)$$

for worthy

$$Z = \begin{cases} 0, & z \le 50 \\ (z-50)/100-50), & 50 \le z \le 100 \\ 1, & z \ge 100 \end{cases} \quad (6)$$

, for unworthy

4. Defuzzification
   Using the Average (Average) method, the input of the defuzzification is a fuzzy set (generated from the composition process) and the output is a value (crisp) as shown in equation (7). The weighted average is used to determine the final result of the output shown in equation (8).

$$Z^* = \sum \frac{\alpha i z1}{\alpha i} \quad (7)$$

$$z = \frac{\alpha 1 + \alpha 2 z2}{\alpha 1 + \alpha 2} \quad (8)$$

2.5. Proposed Method

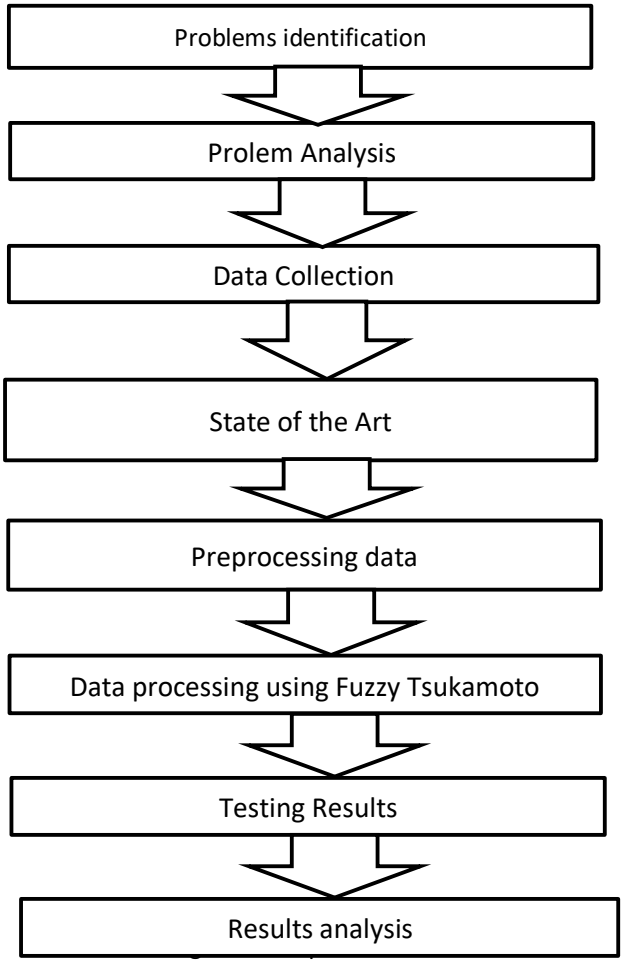


Figure 5

In this study, a research framework was created with the aim that research can be carried out in stages and consistently and is an outline of the steps carried out in research as shown in Figure 5.

1. Identifying the Problem. Identifying the problem being researched. The main problem faced is implementing the Tsukamoto fuzzy logic method in selecting prospective beneficiaries to determine community assistance evenly and on target.
2. Analyzing the Problem. The problem found in identifying this problem is that it is still difficult for village officials to select prospective beneficiaries.
3. Collecting Data. Collecting data on village apparatus related to interviews, in a case that will be resolved by taking data from local residents in the village archives, in Karseman Village, Rembang.

4. Studying Literature. Reference to obtain certain information related to research cases obtained in the form of books or other writings in previous research.
5. Analyzing Data Processing with the Fuzzy Logic Tsukamoto method. After the data is collected, perform an analysis of the data processing method, namely the Fuzzy Logic Tsukamoto method in obtaining a weighted value with the aim of solving research problems with the algorithm.
6. Application of Tsukamoto's fuzzy logic method. Applying the Tsukamoto fuzzy logic method into a system that has been made to be able to operate and to process data in research, where the results that are completed with this method are to get the expected results according to the predetermined variables, so as to produce a decision as desired.
7. Doing Tests. Conducting data testing, aiming to form a system that is used to produce output, by measuring the decision whether it has succeeded in making decisions correctly, a comparison of the results of system testing with manual searches is carried out.
8. Analyzing Test Results. Data that has been entered in the testing phase will be analyzed and evaluated, to obtain information whether the data is correct or not.

2.6. Data Collection

The important thing for a research to be successful is the collection of data. This relates to the way researchers collect data and the origin from which they are obtained. Kasreman Village, Rembang provides assistance to villagers, and those who are entitled to citizen assistance are as follows:

1. The recipients of citizen assistance are prioritized for people from poor families.
2. Recipients who meet the requirements to receive assistance such as residents with low incomes, many dependents, have labor jobs and are seen from the perspective of residence.

Collection of data or data sets from all population data that is still unstructured. The data set used as research material was obtained from the Kasreman village office, Rembang district, which totaled 550 data as shown in Figure 6. The variables used in this research as shown in Table 3.

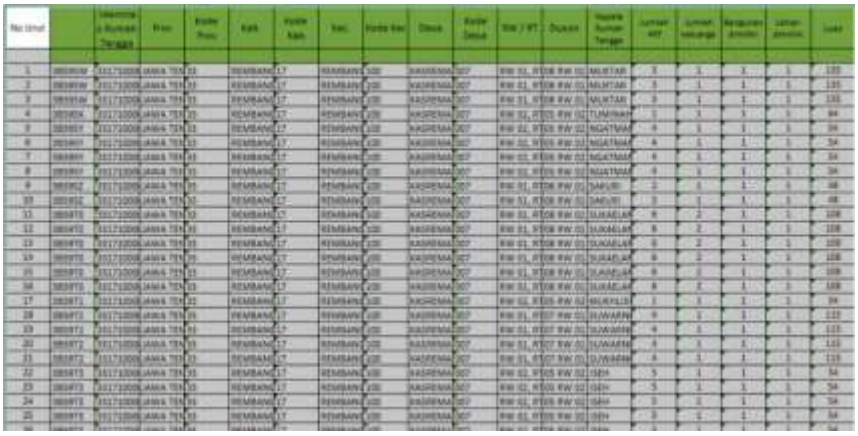


Figure 6. Example Dataset

Table 3. Variables

No	Variabel	Score point
1.	Citizen Criteria	Land area
2.	Income Criteria	Family Income
		Family Dependents

Unstructured data is converted into data according to the needs, a data cleaning process is carried out to remove incomplete, inaccurate data. Existing data is carried out by a cleaning process to remove data that is not needed. The data used has 3 attributes, namely land area, number of family dependents and income. Unused population data has been removed from the cleaning process. The training data used by the algorithm to form a policy for assessing the weight of the criteria for the recipients of citizen assistance. In this study, there are 3 points of assessment of the weight of the criteria for recipients of citizen assistance, such as high, medium and low. The interval that has been determined by the village apparatus will determine the points earned from the residents' sources of income. Each number of dependents has its own points, because the number of dependents affects the net family dependents, Maximum points for each number of dependents as shown in Table 5.

Table 4. Family Income Variable Weight

Fuzzy Value	Income
Low	< 2.000.000
Medium	2.000.000 - 3.000.000
High	>3.000.000

Table 5. Family Dependent Variables

Fuzzy Value	Dependents
Low	<2
Medium	2 until 4
High	>4

Table 6. Land Area

Fuzzy Value	Area
Low	<200
Medium	180 - 350
High	>500

3. RESULTS AND DISCUSSION

In this study, 3 criteria have been used with a decision in the form of being accepted or rejected. The criteria used include land area, income and dependents. In the 3 criteria that can be used in the formation of fuzzy logic membership, namely Low, Medium, and High. In this research, it has been tested with villagers who have a land area of 220 houses, 5 dependents, an income of Rp. 2,000,000, so the status of the residents will be sought whether they are accepted or rejected to get community assistance. The following is an accuracy test carried out to determine the level of accuracy of the training data as shown in Table 8.

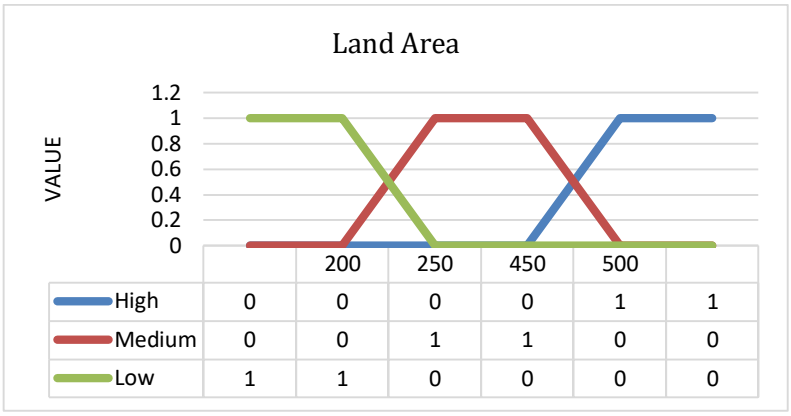


Figure 7. Membership Function Variable Land Area

From the data in Figure 7, it is obtained that the membership function in the decision is accepted and rejected as follows:

$$\text{Low Area [x]} = \begin{Bmatrix} 1 & x \le 200 \\ 250 - x \,/\, 250 - 200 & 200 \le x \le 250 \\ 0 & x \ge 250 \end{Bmatrix}$$

$$\text{Middle Area [x]} = \begin{Bmatrix} 1 & \\ \dfrac{x - 200}{250 - 200} & 250 \le x \le 450 \\ \dfrac{500 - x}{500 - 450} & 200 \le x \le 250 \\ 0 & 450 \le x \le 500 \\ & x \le 200; x \ge 500 \end{Bmatrix}$$

$$\text{Wide Area [x]} = \begin{Bmatrix} 1 & x \ge 500 \\ (x - 450)/(500 - 450) & 450 \le x \le 500 \\ 0 & x \le 450 \end{Bmatrix}$$

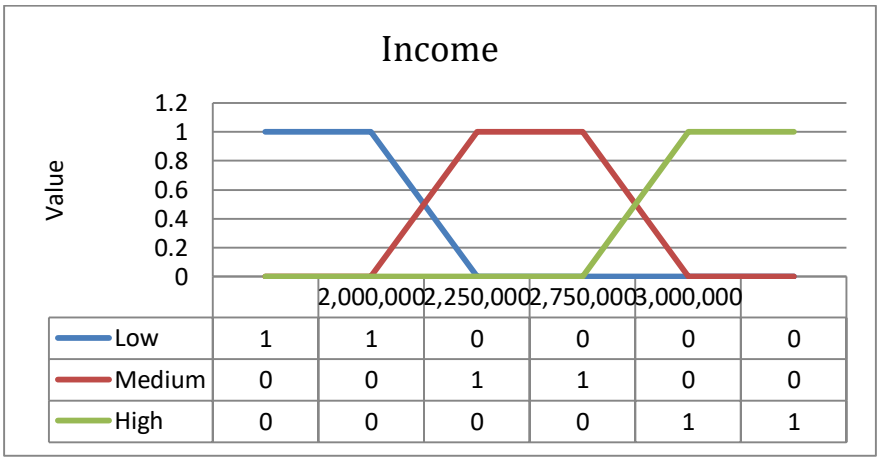


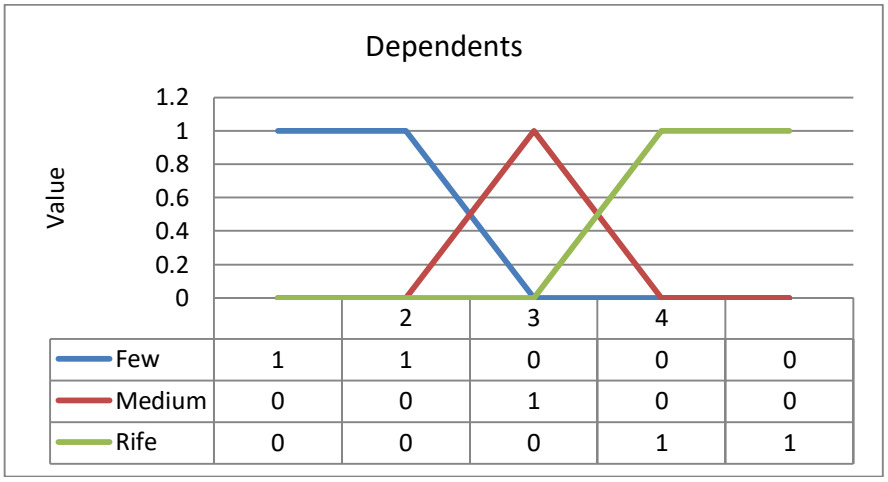
Figure 8. Membership Function Variable Income

From the data in Figure 8, the membership function is obtained in the decision to accept and reject.

$$low\ income\ [x] = \begin{Bmatrix} 1 & x \le 2000000 \\ 2250000 - x \,/\, 2250000 - 2000000 & 2000000 \le x \le 2250000 \\ 0 & x \ge 2250000 \end{Bmatrix}$$

$$average\ income\ [x] = \begin{Bmatrix} 1 & 2250000 \le x \le 2750000 \\ (x - 2000000)/(2250000 - 2000000) & 2000000 \le x \le 2250000 \\ (3000000 - x)/(3000000 - 2750000) & 2750000 \le x \le 3000000 \\ 0 & x \le 2000000; x \ge 3000000 \end{Bmatrix}$$

$$high\ income\ [x] = \begin{Bmatrix} 1 & x \ge 3000000 \\ (x - 2750000)/(3000000 - 2750000) & 2750000 \le x \le 3000000 \\ 0 & x \le 2750000 \end{Bmatrix}$$



Few	1	1	0	0	0
Medium	0	0	1	0	0
Rife	0	0	0	1	1

Figure 9. Membership Function Variable Dependents

$$\text{Few dependent [x]} = \begin{Bmatrix} 1 & x \le 2 \\ 3 - x\ /\ 3 - 2 & 2 \le x \le 3 \\ 0 & x \ge 3 \end{Bmatrix}$$

$$\text{Medium dependen [x]} = \begin{Bmatrix} 1 & x = 3 \\ (x - 2)/(3 - 2) & 2 \le x \le 3 \\ (4 - x)/(4 - 3) & 3 \le x \le 4 \\ 0 & x \le 2; x \ge 4 \end{Bmatrix}$$

$$\text{Rife dependen [x]} = \begin{Bmatrix} 1 & x \ge 4 \\ (x - 3)/(4 - 3) & 3 \le x \le 4 \\ 0 & x \le 3 \end{Bmatrix}$$

Process of making the inference engine, the value of the calculation in the decision fuzzyfication process is sought. In the process of finding the value using the function to get the minimum value from the existing data. From the case study above, it can be calculated using the fuzzy process described in rule 1 as "If the land area is low and income is low and dependents are low, then it is accepted" as shown in Table 7 and we had 27 rules.

Table 7. Formation of Rules

Rule		Area		Income		Dependent		Decision
1	if	low	and	low	and	low	then	received
2	if	low	and	low	and	medium	then	received
3	if	low	and	low	and	high	then	received
4	if	low	and	medium	and	low	then	received
5	if	low	and	medium	and	medium	then	received
6	if	low	and	medium	and	high	then	received
7	if	low	and	high	and	low	then	rejected
8	if	low	and	high	and	medium	then	rejected
9	if	low	and	high	and	high	then	rejected
10	if	medium	and	low	and	low	then	received
11	if	medium	and	low	and	medium	then	received
12	if	medium	and	low	and	high	then	received

13	if	medium	and	medium	and	low	then	rejected
14	if	medium	and	medium	and	medium	then	rejected
15	if	medium	and	medium	and	high	then	rejected
16	if	medium	and	high	and	low	then	rejected
17	if	medium	and	high	and	medium	then	rejected
18	if	medium	and	high	and	high	then	rejected
19	if	high	and	low	and	low	then	received
20	if	high	and	low	and	medium	then	received
21	if	high	and	low	and	high	then	received
22	if	high	and	medium	and	low	then	rejected
23	if	high	and	medium	and	medium	then	rejected
24	if	high	and	medium	and	high	then	rejected
25	if	high	and	high	and	low	then	rejected
26	if	high	and	high	and	medium	then	rejected
27	if	high	and	high	and	high	then	rejected

Table 8. Prediction

Class	Worthy	Unworthy
Worthy	121 (TP)	5 (FN)
Unworthy	9 (FP)	58 (TN)
Test Data		165

From Tabel 8, data can be calculated using the following formula:
Accuracy = (TP + TN) / (TP + TN + FP + FN) * 100
Precision = (TP) / (TP + FP)
Recall = (TP) / (TP + FN)

Given: TP = 121, FP = 9, FN = 5, TN = 58
Accuracy = (TP + TN) / (TP + TN + FP + FN) * 100%
= (121 + 58) / (121 + 58 + 9 + 5) * 100%
= 179 / 193 * 100%
= 0.927 * 100%
= 92.7%
Precision = (TP) / (TP + FP)
= 121 / 121 + 9 = 0.93

Recall = (TP) / (TP + FN)
= 121 / 121 + 5 = 0.96

Thus, the results of testing the feasibility of residents receiving citizen assistance using the fuzzy logic of the Tsukamoto method got an accuracy of 92.7% and is the result of testing training data, so that the smoothness of the eligibility of prospective beneficiaries has been predicted from the start in order to minimize inaccuracies when providing assistance.

The following is the calculation of the application accuracy in predicting receiving assistance using the fuzzy logic of the tsukamoto method:
Percentage of accuracy = (amount of correct data) / (Number of test data) * 100%
Known: the number of correct data = 179
Total test data = 193
Answer : Percentage of accuracy = (amount of correct data) / (Amount of test data) * 100%
= 179/193* 100%
= 92.74%

Based on the calculation of the accuracy produces an accuracy of 92.74%. In this case, the imported data will be tested into citizen data. The system will display data that has been imported and then processed so as to produce an accuracy value of citizen data testing.

4. CONCLUSION

A decision support system has been made with the Fuzzy Tsukamoto method that is able to produce a decision about whether or not residents are worthy of getting citizen assistance. Based on the test results obtained a good accuracy of 92.74% so that it can be said that the Decision Support System for Accepting Citizen Assistance can be used without problems. Further research can add other variables in order to be able to create a more detailed decision support system regarding the existing criteria. Further research can be carried out in stages of analysis that describe the variables that have the most influence on decision considerations.

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