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Analysis Model of Detection Level of Food-Stood Railway and Reservation with Fuzzy Set Theory in Yogyakarta

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Abstract. In Indonesia, the soil conditions of each region are of course different, depending on the type of soil and the geographical location of a place or an area that affects the soil quality. For farmers, especially in the countryside, to understand the knowledge of good soil quality is difficult and it takes a long time to determine the right types of plants to plant in accordance with the soil. For that, it needs a strategy in knowing a polluted land or not especially for farmers. The purpose of this paper is to assist the process of dissemination of information and knowledge through calculations using fuzzy logic. In this research, the data that is processed is the land aspect data as a benchmark in determining whether or not soil contamination includes soil pH or soil acidity, soil minerals, soil structure and soil nutrients. At this writing is done fuzzy calculation analysis with Sugeno method. In this paper shows that the results obtained by the Sugeno method have results that are less in accordance with the actual data.

Keywords: Analysis Model, Food-stood, Fuzzy Set, Railway, Reservation.

Running title: Analysis model of detection level of food-stood railway and reservation.

INTRODUCTION

Especially for the agricultural sector, good and uncontaminated land is very much needed. In the agricultural sector, land is an important factor in determining agricultural business. In Indonesia, the condition of the land of each region is different that it depends on the type of soil and the geographical location of a place or an area that affects the quality of the soil in the area (Yulianto, 2015). Therefore, the quality of soil is maintained and preserved in its function for the maintenance of health and human welfare and protection for other living creatures. In addition to the community, healthy soil is also one of the determinants of success for the agricultural sector, because many cases of agricultural business fail only because of contaminated or unhealthy soil problems (Mintara and Wahyu Setyo, 2017). This can occur due to a lack of understanding about the criteria for good soil or uncontaminated land. The majority of farmers only rely on how to plant well without paying attention to the quality of the land.

For farmers, especially in the countryside, to understand the knowledge of good soil quality is certainly difficult and requires a relatively long time to determine the right type of plant to plant which is in accordance with the soil. Especially for farmers (Yulianto. 2015). At this writing, we will explain how to predict land that is not polluted and safe for both the community and the agricultural sector in helping to make decisions through the selection of healthy and uncontaminated soil types.

Besides that, it can help the process of disseminating information and knowledge through calculations using fuzzy logic, the calculations made in this paper use fuzzy logic with the *Sugeno* method to overcome many data values that compare the uncertainty of data obtained by the authors through various sources from every aspect of soil samples that have been tested (Nidomudin Ahmad, 2017). This research was conducted at Yogyakata State University.

There are several relevant researches on fuzzy which are applied to predict soil conditions, including research with the title "Expert System for Determining Soil Fertility Levels Using Fuzzy Logic" by Ahmad Nidomudin in 2017, research with the title "pH-Based Control and Soil Moisture Fuzzy Logic Using Microcontrollers "by Jimmi Martin in 2015, while relevant research on fuzzy applied to predict pollution, among others, research with the title" Detection System for Polluted Air Pollution in Lapindo Mud Area by Using Fuzzy Logic "by Reza Hastuti on in 2017. The advantages of this writing are compared with research - previous research is in this writing predicting the contaminated soil condition using manual calculation, namely by the *Sugeno* method so as not to use the system so that it is more easily adapted to the actual soil conditions.

MATERIALS AND METHODS

Method

In this research, using the *Sugeno* method Order-Zero model has a similar reasoning to the *Mamdani* Fuzzy model. However, if the output of reasoning with the Fuzzy *Mamdani* model is in the form of a constant or linear equation, in the Fuzzy *Sugeno* model in the form of a Fuzzy set (Mahmud, Zulkifli. 2016). Here is the flowchart of the research method:

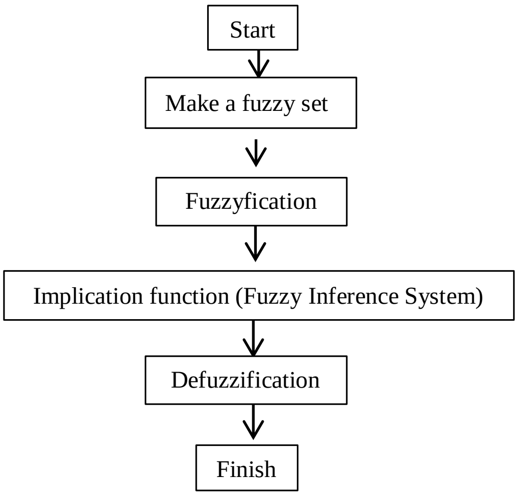

Figure 1. Flowchart Sugeno Method.

Data Analysis

In this study, the data that is processed is the aspect data of the soil as a benchmark in determining whether or not the soil is contaminated in each place by using the fuzzy method, the Sugeno method. There are five aspects of land elements that become input variables which will be pursued into 3 main aspects:

1.1 Variable Degrees of Acidity or pH of Soil

One of the soil parameters that affect soil fertility is the degree of acidity (pH) which can be expressed in the range of 1 to 14 (Kotu, Silwasty. 2015). The pH value of neutral soils is 7, but the pH value of normal and healthy soil is above 5.5 so less than 5.5 is said to be acidic and more than 7 is said to be alkaline. Almost all plants can grow and prefer to develop in slightly acidic and slightly alkaline soils between pH 5.5 - 7.5 depending on the type of plant (Yulianto, 2015).

Table 1. Variable degree of soil acidity.

Category	Domain
Acid	[0,5.5]
Normal	[5.5,6.5]
Base	[>7.5]

1.2 Variables in Soil Nutrients

Nutrients are important in plants that can help plant growth. Nutrients usually require water content as a solvent in taking and transporting (Kotu, Silwasty. 2015). However, nutrient elements in a place usually gradually diminish and even disappear when a lot of waste (both factory waste and residential waste) is close to the soil. This can be measured based on the proximity or absence of the plant or the settlement of residential settlements or the large percentage of organic carbon (organic C) in the soil (Yulianto, 2015).

Table 2. Variable of soil nutrients.

Category	Percentage of Organic C (%)
Less	[0,1.5]
Enough	[1.5,3.0]
Normal	[>3.0]

1.3 Variable of Soil Mineral Content

The soil mineral content can usually help plants become fertile and not easily withered. This is because soil mineral content is needed by microorganisms and fungi that help soil fertility. However, if a soil does not contain any fungi or microorganisms in it, the soil does not contain soil minerals. Healthy and uncontaminated soil is soil that contains minerals in it which can be measured from a large proportion of total potassium (K Total) per gram of soil sample taken (Yulianto, 2015).

Table 3. Variable of Soil Mineral Content.

Category	K Total (mg/100gr)
Less	[0,20]
Enough	[20,40]
Normal	[>40]

Analysis of Membership Degrees (Fuzzification)

1.4 Function of the Degree of Membership of Variables in the Degree of Soil Acidity.

In the function below is a membership function of the soil acidity degree to calculate the value of x degree of soil acidity, can be expressed in the following equation:

$$[x]\begin{cases} 1, & x = 0 \\ \frac{4.5\text{-}x}{4.5\text{-}0}, & 0 < x < 4.4 \\ 0, & x \geq 4.4 \end{cases} \quad (1),$$

$$[x]\begin{cases} 0, & x < 4.4 \\ \frac{5.5\text{-}x}{5.5\text{-}4.4}, & 4.4 \leq x < 5.5 \\ 1, & 5.5 < x < 6.0 \\ \frac{7.5\text{-}x}{7.5\text{-}6.0}, & 6.0 < x < 7.5 \\ 0, & x \geq 7.5 \end{cases} \quad (2),$$

$$[x]\begin{cases} 0, & x \leq 6.0 \\ \frac{7.5\text{-}x}{7.5\text{-}6.0}, & 6.0 < x < 7.5 \\ 1, & x \geq 7.5 \end{cases} \quad (3)$$

1.5 Functions of Membership Levels of Soil Nutrients.

In the function below to calculate the membership value of soil nutrients, can be expressed in the following equation:

$$[x]\begin{cases} 1, & x = 0 \\ \frac{1.5\text{-}x}{1.5\text{-}0}, & 0 < x < 1.5 \\ 0, & x \geq 1.5 \end{cases} \quad (4),$$

$$[x]\begin{cases} 0, & x \le 1.5 \\ \frac{3.0\text{-}x}{3.0\text{-}1.5}, & 1.5 < x < 3.0 \\ 1, & x = 3.0 \\ \frac{3.1\text{-}x}{31\text{-}30}, & 3.0 < x < 3.1 \\ 0, & x \ge 3.1 \end{cases} \quad (5), \quad [x]\begin{cases} 0, & x \le 3.1 \\ \frac{3.1\text{-}x}{3.1\text{-}3.0}, & 3.0 < x < 3.1 \\ 1, & x \ge 3.1 \end{cases} \quad (6)$$

1.6 Functions of Degree of Membership of Soil Mineral Content

In the function below to calculate the value of x soil mineral content, can be expressed in the following equation:

$$[x]\begin{cases} 1, & x = 0 \\ \frac{20\text{-}x}{20\text{-}0}, & 0 < x < 20 \\ 0, & x \ge 20 \end{cases} \quad (7),$$

$$[x]\begin{cases} 0, & x \le 20 \\ \frac{40\text{-}x}{40\text{-}20}, & 20 < x < 40 \\ 1, & x = 40 \\ \frac{45\text{-}x}{45\text{-}40}, & 40 < x < 45 \\ 0, & x \ge 50 \end{cases} \quad (8),$$

$$[x]\begin{cases} 0, & x \le 40 \\ \frac{50\text{-}x}{50\text{-}45}, & 40 < x < 50 \\ 1, & x \ge 50 \end{cases} \quad (9)$$

Rule

This rule as a tool to find out the condition of a healthy soil or not on the soil conditions to be analyzed. Rule rules are written in the form of IF-THEN, rule data used in analyzing using fuzzy logic methods.

Table 4. Fuzzy Rule for Estimating Soil Pollution.

No	Rule	Acidity (pH)	Nutrient	Mineral	Land Conditions
1	R1	Acid	Less	Less	Polluted
2	R2	Acid	Less	Enough	Polluted
3	R3	Acid	Less	Normal	Polluted
4	R4	Normal	Less	Less	Resident Safe
5	R5	Normal	Less	Enough	Resident Safe
6	R6	Normal	Less	Normal	Arable Land
7	R7	Base	Less	Less	Resident Safe
8	R8	Base	Less	Enough	Resident Safe
9	R9	Base	Less	Normal	Resident Safe
10	R10	Acid	Enough	Less	Polluted
11	R11	Acid	Enough	Enough	Polluted
12	R12	Acid	Enough	Normal	Polluted
13	R13	Normal	Enough	Less	Resident Safe
14	R14	Normal	Enough	Enough	Resident Safe
15	R15	Normal	Enough	Normal	Arable Land
16	R16	Base	Enough	Less	Polluted
17	R17	Base	Enough	Enough	Resident Safe
18	R18	Base	Enough	Normal	Resident Safe
19	R19	Acid	Normal	Less	Polluted
20	R20	Acid	Normal	Enough	Polluted
21	R21	Acid	Normal	Normal	Polluted
22	R22	Normal	Normal	Less	Polluted
23	R23	Normal	Normal	Enough	Arable Land
24	R24	Normal	Normal	Normal	Arable Land
25	R25	Base	Normal	Less	Resident Safe
26	R26	Base	Normal	Enough	Resident Safe
27	R27	Base	Normal	Normal	Polluted

After knowing the fuzzy rules the application function will then look for the shape of the soil by using the equation of the Order-Zero *Sugeno* method as follows:

$$\mathrm{IF}(x_1 \mathrm{is} A_1) \cap (x_2 \mathrm{is} A_2) \cap (x_3 \mathrm{is} A_3) \cap \ldots \cap (x_N \mathrm{is} A_N) \mathrm{THEN} z = k$$

Description: x_N is the input variable, A_N is a category [8].

$$z = \begin{cases} \text{Polluted} & k \le 0.33 \\ \text{Resident Safe} & 0.33 < k \le 0.66 \\ \text{Arable Land} & 0.66 < k \le 0.99 \end{cases}$$

At this time the implication function that will be used is to use the minimum function, namely by looking for i-rule and can be stated in the equation formula as follows:

$$a_i = \mu_{A_i}(x) \cap \mu_{B_i}(x) = \min\{\mu_{A_i}(x), \mu_{B_i}(x)\}$$

Note:

a_i = The minimum x value of the fuzzy set A and B in the i-rule

$\mu_{A_i}(x)$ = The minimum x value of the fuzzy set A in the i-rule

$\mu_{B_i}(x)$ = The minimum x value of the fuzzy set B in the i-rule

***Fuzzy* Inference System**

The composition of the rules using the max function, namely the fuzzy set solution is obtained by taking the maximum value of the rule (Puspita, Ema Sastri. 2016). If all propositions have been evaluated, the output will contain a fuzzy set that reflects the contribution of each proposition. In general, it can be written:

$$U_{sf}[x_i] = \max(U_{sf}[x_i], U_{kf}[x_i])$$

Note:

$U_{sf}[x_i]$ is the membership value of the fuzzy solution until the i-rule

$U_{kf}[x_i]$ is the membership value of the fuzzy consensus until i-rule

RESULTS AND DISCUSSIONS

Defuzzification

Defuzzification is converting the fuzzy set output to a strict form. In *Sugeno* method use a weighted average calculation.

$$WA = \frac{\sum_{i=1}^{N} \alpha_i z_i}{\sum_{i=1}^{N} \alpha_i}$$

WA is the weighted average value, α_i is α-predicate - i, z_i is consequent - i

The case of the *sugeno* Method in Estimating Soil Pollution.

Table 5. Samples of Land Data in several Kulonprogo Regencies in Yogyakarta

No	City	Location	Aciticy	Mineral	Nutrient
1	Kulon Progo	Ngudirejo, Jurug Sidorejo	7.87	1.09	21.14
2	Kulon Progo	Tani Makmur, Jatirejo	7.41	8.69	50.42
3	Kulon Progo	Bumirejo, Ngipik	7.58	10.9	19.02
4	Kulon Progo	Tanirejo, Mesan 2	7.26	1.60	24.14
5	Kulon Progo	Ngudi Rukun	7.77	2.29	31.07
6	Kulon Progo	Ngudi Rahayu Gegulu	6.89	1.08	20.38

Source: Data from the Regional Environmental Management Performance Information Document (IKPLHD) of Special Region of Yogyakarta (2016).

The calculation will be taken with the *Sugeno* method in predicting the contamination of land on the land conditions of **Ngudirejo area, Juirug Sidorejo Kulon Progo Regency** which has a pH of 7.87, the nutrient content of 21.14%, the mineral content of 1.09 x 105 / gr soil samples and the type of soil structure is clay.

Step 1. Determine the fuzzy set.

a. For the pH input variables defined 3 fuzzy sets, namely: Acid, Normal and Base (with intervals in equations $(1), (2)$ and (3). So from the three equations obtained:

$$\mu_{acid} = \mu_{normal} = 0, \mu_{base} = \frac{(8.5\text{-}\ 7.87)}{(8.5\text{-}6.5)} = 0.315,$$

which means that the pH can be said to be alkaline with a membership degree of 0.315.

For input variables Nutrient is defined as 3 fuzzy sets, namely: Less, Sufficient and Normal (with intervals in equations $(7), (8)$ and (9). So that the three equations are obtained:

$$\mu_{less} = \mu_{normal} = 0, \mu_{enough} = \frac{(21.14\text{-}15)}{(50\text{-}15)} = 0.175,$$

which means that the nutrient content can be said to be sufficient with a membership degree of 0.175.

b. For input variables, Minerals are defined as 3 fuzzy sets, they are: Less, Sufficient and Normal (with intervals in equations $(4), (5)$ and (6), so that the three equations are obtained:

$$\mu_{less} = \frac{2\text{-}1.09}{2\text{-}0} = 0.455, \mu_{enough} = \mu_{normal} = 0,$$

which means that the mineral content can be said to be less with a membership degree of 0.455.

Step 2. Application of Function Implications

The implication function used in this process is the MIN (minimum) function, which is by taking the minimum membership level of the input variable as its output.

[R14] If the pH is normal, enough nutrients and minerals are suficient, the soil is safe for residents.
α-predicat$_{14}$= $\mu_{pH\_normal} \cap \mu_{nutrient\_enough} \cap \mu_{mineral\_enough} = \min(0.06\ , 0.979\ , 0.669) = 0.06.$

According to Table 4, the linguistic variable is polluted.

[R17] If the base pH, sufficient nutrient elements and minerals are sufficient, the soil is safe for residents.
α-predicat$_{17}$= $\mu_{pH\_base} \cap \mu_{nutrient_{enough}} \cap \mu_{mineral_{enough}} = \min(0.445\ , 0.979\ , 0.669) = 0.445.$

According to Table 4, the linguistic variable is resident safe.

[R11] If pH is acid, nutrient elements are sufficient and enough minerals are polluted.
α-predicat$_{11}$= $\mu_{pH_{acid}} \cap \mu_{nutrient_{enough}} \cap \mu_{mineral_{enough}} = \min(0\ , 0.979\ , 0.669) = 0.$

According to table 4, the linguistic variable is polluted.

[R16] If the pH is base, nutrient elements are sufficient and minerals are lacking, so the soil is polluted.
α-predicat$_{16}$= $\mu_{pH\_base} \cap \mu_{nutrient\_enough} \cap \mu_{mineral\_less} = \min(0.18\ , 0.979\ , 0) = 0.$

According to Table 4, the linguistic variable is Resident Safe.

Step 3. Composition of Rules

The composition of the rules is the overall conclusion by taking the maximum membership level of each consequence application function implicating and combining all the conclusions of each rule, so as to obtain a fuzzy solution area. The composition of the rules uses the max function as follows:

$$U_{sf}[x_i] = \max(U_{sf}[x_i], U_{kf}[x_i])$$

So that the composition of the rules of max contaminated land function is obtained as follows:

1. Polluted Land = max(0.06) = 0.18
2. Safe Resident Land = max(0.445) = 0.445
3. Arable Land = max(0) = 0

Step 4. Confirmation (defuzzification)

The *Sugeno* method confirms using weighted average calculations

(WeightedAverage):

$$WA = \frac{\sum_{i=1}^{N} \alpha_i z_i}{\sum_{i=1}^{N} \alpha_i} = \frac{0.06(0.33) + 0.445(0.66) + 0(0.99)}{0.06 + 0.445 + 0} = 0.621$$

So, by using the *Sugeno* fuzzy inference system method on the land conditions of the **Tani Makmur area, Jatirejo Kulon Progo Regency** where it has a pH of 7.41, nutrient content of 50.42%, mineral content of 8.69 x 10^5 / gr soil samples and soil structure types are clay has deffuzification value land contamination of 0.621 with linguistic variables is Safe Population**.**

Based 6 data above calculated by the steps as above obtained the following results:

Table 6. The results of the Manual count with the *Sugeno* Method.

No	City	Location	Land Predict	Defuzzification Score	Variable *Linguistic*
1.	Kulon Progo	Ngudirejo, Jurug Sidorejo	[Polluted]	0.33	Polluted
2.	Kulon Progo	Tani Makmur, Jatirejo	[Polluted]	0.621	Polluted
3.	Kulon Progo	Bumirejo, Desa Ngipik	[Polluted]	0.33	Polluted
4.	Kulon Progo	Tanirejo, Mesan 2	[Polluted]	0.33	Polluted
5.	Kulon Progo	Ngudi Rukun	[Polluted]	0.33	Polluted
6.	Kulon Progo	Ngudi Rahayu Gegulu	[Resident Safe, Polluted]	0.33	Polluted

In the table above shows that the results obtained by the *Sugeno* method have results that are not in accordance with the actual data. This is because of the 69 data only has 36 data that matches the actual data, the percentage of errors with the *Sugeno* method is 47.8%. This can be shown from the difference between the actual data and the results of the processing using the *Sugeno* method.

CONCLUSION

Thus it can be concluded that the *Sugeno* method is well used to predict land pollution, especially in areas with the sample above because it only has an error rate of 47.8%. For further research, the authors give several suggestions including: Using more training data, Adding variables to the study such as rainfall that affects the pH or variables that cause other pollutants that are watery and Using other FIS methods, Tsukamoto method or Mamdani method.

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