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Analysis of flood insurance premium amount using Fuzzy Inference of Sugeno Method

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Abstract

The study aims to investigate the analysis of flood insurance premium amount using the Fuzzy Inference of Sugeno Method by considering the criteria of community income, community expenditure, and flood zone. As a result, the premiums paid by each

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household are IDR 9,688.65 per month for residents of Bojongsoang District, and IDR 10,256.27 per month for residents of Baleendah District. In conclusion, three criteria are affecting the decision determination of premium value, namely the average income of the community, their expenditure monthly, and the flood zone area of community Bojongsoang and Baleendah District in Citarum River.

Keywords: Flood insurance, Premium, Sugeno method.

Análisis del monto de la prima del seguro contra inundaciones utilizando el método de inferencia difusa de Sugeno

Resumen

El objetivo del estudio es investigar el análisis del monto de la prima del seguro contra inundaciones utilizando el método de inferencia difusa de Sugeno al considerar los criterios de ingreso comunitario, gasto comunitario y zona de inundación. Como resultado, las primas pagadas por cada hogar son 9.688,65 IDR por mes para los residentes del distrito de Bojongsoang, y 10.256,27 IDR por mes para los residentes del distrito de Baleendah. En conclusión, tres criterios están afectando la determinación de la decisión del valor de la prima, a saber, el ingreso promedio de la comunidad, sus gastos mensuales y el área de la zona de inundación de la comunidad Bojongsoang y el distrito de Baleendah en el río Citarum.

Palabras clave: Seguro contra inundaciones, Prima, método Sugeno.

1. INTRODUCTION

Based on Handling Health Problems Report caused by Natural Disaster Flood in Baleendah District Bandung Regency in the year of 2013, topographically, Bandung regency is located in the highlands, between latitudes 10.22^0 to 108.5^0 (East Longitude), and 6.4^0 to 7.19^0 (Southern Latitude), with an altitude between 110 to 2.429 meters

above sea level. Where the air temperature between 19^0 to 20^0 Celsius, and has a tropical climate wet with high rainfall. Bandung regency is a basin area and also a meeting point of several large and small rivers (SUKONO, AISAH, TAMPUBOLON, NAPITUPULU, SUPIAN, & SIDI, 2018a). Therefore, Bandung regency is prone to flood because some areas are on the banks of Citarum River and its tributaries flow into Citarum River like Baleendah District, Majalaya District, Ibun District, Banjaran District, Pameungpeuk District, Dayehkolot District, Paseh District, Soreang District, Katapang, and Rancaekek District (SUKONO, SUYUDI, SUPIAN, HIDAYAT, BUDIONO, HASSAN, LANANAN, & UMAR, 2018c).

Until now there has been no effective solution to avoid flooding and ways to protect flood-affected assets. However, people can take some protective measures for the safety of themselves and the assets held by participating in the flood insurance program (SIDI, MAMAT, SUKONO, & SUPIAN, 2017a). A flood insurance program is a shared risk mitigation system; some percentage is the responsibility of the insured property owner. The amount of flood insurance premium is determined based on the condition of the location of the insured property and several other factors (SIDI, MAMAT, SUKONO, & SUPIAN, 2017b).

To determine the amount of flood insurance premiums, a systematic decision support system is needed, so it is worth paid by the participating communities. One of the decision support systems that can be used is the Fuzzy Inference System (FIS) of the Sugeno method (SUKONO, SUBARTINI, DAMAYANTI, GHAZALI, GASIM, & RIAMAN, 2018b). Fuzzy Inference System (FIS) is a method using

fuzzy set theory to map the input to output. In 1965, Prof. Lotfi A. Zadeh from California University USA made an invaluable contribution to the development of fuzzy set theory, so now a day, fuzzy concepts are applied in various areas of life (JAIN & SONI, 2015).

Many previous studies use the Fuzzy Inference System for systematic decision making such as by CAVALLARO (2015) that works on a method of Takagi-Sugeno Fuzzy Inference System for developing a sustainability index of biomass. The study applies the Sugeno Fuzzy Inference System method for assessing the sustainability of organic plant energy. BLEJ & AZIZI (2016) study the comparison of the Mamdani and Sugeno method for fuzzy real-time scheduling. The study compared two methods of Fuzzy Inference System which the methods of Mamdani and Sugeno in real-time fuzzy scheduling. CHAUHARI & PATIL (2014) conducted a study on comparative analysis of the Fuzzy Inference System for air conditioners. JAIN & SONI (2015) examine the comparison of Mamdani and Sugeno Fuzzy Inference System for deciding the set point for a hydropower dam reservoir based on the power generation requirement. SUKONO ET AL. (2018b) studies on the Fuzzy Inference System of Tsukamoto method on deciding on determining the flood insurance premium. The goal is to determine the magnitude of flood insurance premiums that are reasonable and affordable by people living in these two areas (KENCANA. KOROTKOV & ZAGAYNOVA, 2019).

Based on the previous explanations, the authors are motivated to research the analysis of the determination of the amount of flood insurance premiums using the Fuzzy Inference Sugeno Method System. The purpose of this study is to determine the amount of flood insurance premiums, which are eligible to be paid by participating communities of the flood insurance program. The object of the research is the big data of community income, huge public expenditure, the flooding zone area of Baleendah and Bojongsoang District community residences that are in the Citarum River flow area.

2. METHODOLOGIES

In this section, the stages of determining the amounts of premiums reasonably paid by residents of Bojongsoang and Baleendah District using the Fuzzy Inference System Sugeno method are discussed.

2.1. Defining Fuzzy Variables

This step is defining the variables related to the calculation of the amount of premium. In this research, there are four fuzzy variables defined, namely: community income variable, community expenditure variable, flood zone area variable, and premium variable (AHMAD & SAHAR, 2019; SUKONO ET AL., 2018b).

a. Community Income Variable

Community income is the income variable or variable income or salary earned by residents of Bojongsoang and Baleendah District per year

b. Community Expenditure Variables

Community Expenditure is the expenditure of Bojongsoang and Baleendah District residents per year.

c.Flood Zone Area Variable

Flood zone area is the location of the residences of Bojongsoang and Baleendah District based on the height of flood puddles.

d. Premium Variable

Premium is a decent premium paid by the citizens of Bojongsoang and Baleendah District per year.

2.2. Inference Engine

The four variables defined in section 2.1, namely: community income variable, community expenditure variable, flood zone area variable, and premium variable, are combined using a tree diagram as

shown in Figure 1. This tree diagram becomes the fuzzy base rule used in this research to determine the magnitude of flood insurance premiums.

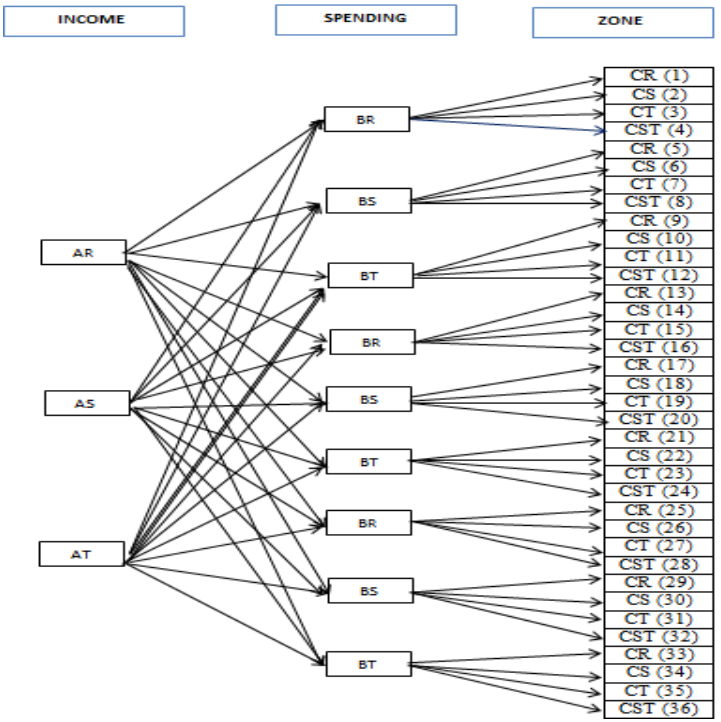

Figure 1: Tree Diagram of the Fuzzy Base Rule

It is known that the low value = 10, the medium = 20, the high = 30 and the very high = 40. The amount of premium can be determined by summing up the income, expenditure, and zone variables. It is said to be low if the amount is ≤ 50, medium if the amount interval is: $50 <$ amount ≤ 80, and high if the amount is > 80.

2.3. Defuzzyfication

The input of this process is a fuzzy set obtained from the composition of fuzzy rules. Whereas the output is a number in the domains of fuzzy set in the form of the amount of premium paid. (CAVALLARO, 2015; AHMAD & AHMAD; 2018):

$$D = \frac{\alpha_1 d_1 + \alpha_2 d_2 + \cdots + \alpha_{35} d_{35} + \alpha_{36} d_{36}}{\alpha_1 + \alpha_2 + \cdots + \alpha_{36} + \alpha_{36}} = \frac{\sum_{i=1}^{36} \alpha_i d_i}{\sum_{i=1}^{36} \alpha_i}.$$

Furthermore, the above methods are used for the analysis of the following determination of the amount of flood insurance premiums.

3. RESULTS AND DISCUSSION

This section, the secondary data processing results using the Fuzzy Inference System of Sugeno Method is shown, for determining the flood insurance premiums in river flow of Citarum flood area Bojongsoang District and Baleendah, Indonesia.

3.1. Data and Information

In this study, the secondary data is used to determine the condition of the population, which is the result of interviews conducted by previous researchers (SUKONO ET AL., 2018c).

The secondary data used for Baleendah District is obtained from the Population Report Recapitulation in the Year 2016 about population. Data from BPS-Statistics of Bandung Regency covers the Publication of Bojongsoang District with Number of the Year 2016, Baleendah District with a number in the Year 2016, and Gross Regional Domestic Product (GRDP) District of Bandung Regency of the Year 2008.

Data is obtained from BPS Indonesia Wage Statistics Publication August 2016 and Executive Summary of Population Expenditure and Consumption of Indonesia. The division of flood zones is obtained from Bandung Flood Risk Map made by the Regional Disaster Management Agency (BPBD) of Bandung Regency. Premium rates are obtained from previous research (AHMAD & AHMAD, 2019; SUKONO ET AL., 2018a).

3.2. Defining Fuzzy Variable and Fuzzification

The input variables are divided into two, namely: data variables of one particular period and data variables at present. Variable data one particular period include income, expenditure, flood zones, and premiums, which are worth the maximum, minimum, and middle value of the premium. Whereas the data variable at this moment is the value inputted according to the state of the decision-maker.

It is known that the main livelihoods of the people of Bojongsoang and Baleendah District are in agriculture (plantations, livestock, fisheries, etc.), traders, laborers, Civil Servants, Armed Forces of the Republic of Indonesia, employers, and service providers.

Based on the data in Table 1, it is known that the residents of Bojongsoang District had GRDP per capita IDR 12, 199, 585. 00 per year in 2007, while residents of Baleendah District had GRDP per capita IDR 6,260,259. 00 per year in 2007. The rate of GRDP per capita was 11.92% per year for Bojongsoang District and 11.69% per annum for Baleendah District. GRDP per capita of Bojongsoang and Baleendah District from 2007 to 2015 are shown in Table 1.

Table 1: GRDP Per Capita Year 2007- 2016 of Bojongsoang and Baleendah District

Year	Districts			
	Bojongsoang		Baleendah	
	Per year Total (IDR)	Average per year (IDR)	Per year Total (IDR)	Average per year (IDR)
2007	12,199,585	1,016,632	6,260,259	521,688
2008	13,653,776	1,137,815	6,992,375	582,698
2009	15,281,307	1,273,442	7,810,109	650,842
2010	17,102,839	1,425,237	8,723,475	726,956
2011	19,141,498	1,595,125	9,743,656	811,971
2012	21,423,165	1,785,264	10,883,143	906,929
2013	23,976,807	1,998,067	12,155,890	1,012,991
2014	26,834,844	2,236,237	13,577,480	1,131,457
2015	30,033,558	2,502,797	15,165,320	1,263,777
2016	33,613,560	2,801,130	16,938,853	1,411,571

The scope of the discussion of a premium variable is between IDR 3,000.00 and IDR 18,000.00, and the median is IDR 10,500.00.

The d_{min} is IDR 3,000.00 as the low premium, d_t is IDR 10,500.00 as the medium premium, and d_{max} is IDR 18,000.00 as a high premium. The membership degree of the entire set for each variable is displayed in Table 2.

Table 2: Degree of Membership

No	Variables	Group	Degree of Membership	Explanation
1	Income	Low	0.6907	District of Bojongsoang
2			0.8696	District of Baleendah
3		Medium	0.6187	District of Bojongsoang
4			0.2606	District of Baleendah
5		High	0.3093	District of Bojongsoang
6			0.1303	District of Baleendah
7	Spending	Low	0.5941	District of Bojongsoang
8			0.7833	District of Baleendah
9		Medium	0.8117	District of Bojongsoang
10			0.4334	District of Baleendah
11		High	0.4059	District of Bojongsoang
12			0.2167	District of Baleendah
13	Zone	Low	0.4667	District of Bojongsoang
14			0.1000	District of Baleendah
15		Medium	0.0000	District of Bojongsoang
16			0.0000	District of Baleendah
17		High	0.1333	District of Bojongsoang
18			0.4000	District of Baleendah
19		Very high	0.5333	District of Bojongsoang
20			0.9000	District of Baleendah

3.3. Determining Inference Engine

After the membership degree of all input variables is obtained, as displayed in Table 2, the next step is to determine the antecedent membership degree for all fuzzy rules of Figure 1.

The values of antecedent membership degree for all fuzzy rules are presented in Tables 3 and 4.

Table 3: The Antecedent Membership Degree of Bojongsoang District

[R]	$\mu_A(a)$	$\mu_B(b)$	$\mu_C(c)$	$\alpha(Bo)$	D
[R1]	0.6907	0.5941	0.4667	0.4667	3,000.00
[R2]	0.6907	0.5941	0.0000	0.0000	3,000.00
[R3]	0.6907	0.5941	0.1333	0.1333	3,000.00
[R4]	0.6907	0.5941	0.5333	0.5333	10,500.00
[R5]	0.6907	0.8117	0.4667	0.4667	3,000.00
[R6]	0.6907	0.8117	0.0000	0.0000	3,000.00
[R7]	0.6907	0.8117	0.1333	0.1333	10,500.00
[R8]	0.6907	0.8117	0.5333	0.5333	10,500.00
[R9]	0.6907	0.4059	0.4667	0.4059	3,000.00
[R10]	0.6907	0.4059	0.0000	0.0000	10,500.00
[R11]	0.6907	0.4059	0.1333	0.1333	10,500.00
[R12]	0.6907	0.4059	0.5333	0.4059	10,500.00
[R13]	0.6187	0.5941	0.4667	0.4667	3,000.00
[R14]	0.6187	0.5941	0.0000	0.0000	3,000.00
[R15]	0.6187	0.5941	0.1333	0.1333	10,500.00
[R16]	0.6187	0.5941	0.5333	0.5333	10,500.00
[R17]	0.6187	0.8117	0.4667	0.4667	3,000.00
[R18]	0.6187	0.8117	0.0000	0.0000	10,500.00
[R19]	0.6187	0.8117	0.1333	0.1333	10,500.00
[R20]	0.6187	0.8117	0.5333	0.5333	10,500.00
[R21]	0.6187	0.4059	0.4667	0.4059	10,500.00
[R22]	0.6187	0.4059	0.0000	0.0000	10,500.00
[R23]	0.6187	0.4059	0.1333	0.1333	10,500.00
[R24]	0.6187	0.4059	0.5333	0.4059	18,000.00
[R25]	0.3093	0.5941	0.4667	0.3093	10,500.00
[R26]	0.3093	0.5941	0.0000	0.0000	10,500.00
[R27]	0.3093	0.5941	0.1333	0.1333	10,500.00
[R28]	0.3093	0.5941	0.5333	0.3093	18,000.00
[R29]	0.3093	0.8117	0.4667	0.3093	10,500.00
[R30]	0.3093	0.8117	0.0000	0.0000	10,500.00
[R31]	0.3093	0.8117	0.1333	0.1333	10,500.00

[R32]	0.3093	0.8117	0.5333	0.3093	18,000.00
[R33]	0.3093	0.4059	0.4667	0.3093	10,500.00
[R34]	0.3093	0.4059	0.0000	0.0000	10,500.00
[R35]	0.3093	0.4059	0.1333	0.1333	18,000.00
[R36]	0.3093	0.4059	0.5333	0.3093	18,000.00

Table 4: The Antecedent Membership Degree of Baleendah District

[R]	$\mu_A(a)$	$\mu_B(b)$	$\mu_C(c)$	$\alpha(Ba)$	D
[R1]	0.8696	0.7833	0.1000	0.1000	3,000.00
[R2]	0.8696	0.7833	0.0000	0.0000	3,000.00
[R3]	0.8696	0.7833	0.4000	0.4000	3,000.00
[R4]	0.8696	0.7833	0.9000	0.7833	10,500.00
[R5]	0.8696	0.4334	0.1000	0.1000	3,000.00
[R6]	0.8696	0.4334	0.0000	0.0000	3,000.00
[R7]	0.8696	0.4334	0.4000	0.4000	10,500.00
[R8]	0.8696	0.4334	0.9000	0.4334	10,500.00
[R9]	0.8696	0.2167	0.1000	0.1000	3,000.00
[R10]	0.8696	0.2167	0.0000	0.0000	10,500.00
[R11]	0.8696	0.2167	0.4000	0.2167	10,500.00
[R12]	0.8696	0.2167	0.9000	0.2167	10,500.00
[R13]	0.2606	0.7833	0.1000	0.1000	3,000.00
[R14]	0.2606	0.7833	0.0000	0.0000	3,000.00
[R15]	0.2606	0.7833	0.4000	0.2606	10,500.00
[R16]	0.2606	0.7833	0.9000	0.2606	10,500.00
[R17]	0.2606	0.4334	0.1000	0.1000	3,000.00
[R18]	0.2606	0.4334	0.0000	0.0000	10,500.00
[R19]	0.2606	0.4334	0.4000	0.2606	10,500.00
[R20]	0.2606	0.4334	0.9000	0.2606	10,500.00
[R21]	0.2606	0.2167	0.1000	0.1000	10,500.00
[R22]	0.2606	0.2167	0.0000	0.0000	10,500.00
[R23]	0.2606	0.2167	0.4000	0.2167	10,500.00
[R24]	0.2606	0.2167	0.9000	0.2167	18,000.00
[R25]	0.1255	0.7833	0.1000	0.1000	10,500.00
[R26]	0.1255	0.7833	0.0000	0.0000	10,500.00
[R27]	0.1255	0.7833	0.4000	0.1255	10,500.00
[R28]	0.1255	0.7833	0.9000	0.1255	18,000.00

[R29]	0.1255	0.4334	0.1000	0.1000	10,500.00
[R30]	0.1255	0.4334	0.0000	0.0000	10,500.00
[R31]	0.1255	0.4334	0.4000	0.1255	10,500.00
[R32]	0.1255	0.4334	0.9000	0.1255	18,000.00
[R33]	0.1255	0.2167	0.1000	0.1000	10,500.00
[R34]	0.1255	0.2167	0.0000	0.0000	10,500.00
[R35]	0.1255	0.2167	0.4000	0.1255	18,000.00
[R36]	0.1255	0.2167	0.9000	0.1255	18,000.00

3.4. Defuzzification

Output Crisp in Fuzzy Inference System of Sugeno method is obtained by centered average defuzzification, so the followings are obtained:

$$D(Bo) = \frac{(0.4667 * 3{,}000) + (0 * 3{,}000) + \ldots + (0.133 * 18{,}000) + (0.3093 * 18{,}000)}{0.4667 + 0 + 0.1333 + \ldots + 0 + 0.133 + 0.3093}$$

$$= \frac{84{,}088.8}{8.6791} = 9{,}688.654354$$

$$D(Ba) = \frac{(0.1000 * 3{,}000) + (0 * 3{,}000) + \ldots + (0.1255 * 18{,}000) + (0.1225 * 18{,}000)}{0.1000 + 0 + 0.4000 + \ldots + 0 + 0.1255 + 0.1225}$$

$$= \frac{57{,}218.7}{5.5789} = 10{,}256.26916$$

By using Fuzzy Inference System of Sugeno method, the Bojongsoang District community with an average income of IDR2, 801,130.00 per month, and expenditure of IDR1,168,131.00 per

month, and its residence in 80 cm underwater should pay the premium amounted to IDR 9,688.65, whereas the Baleendah District community with an average income of IDR1,411,571.00, and expenditure of IDR711,266.00 per month, and its residence in 135 cm underwater should pay the premium amounted to IDR10,256.27.

4. CONCLUSION

In this paper, the determination analysis of flood insurance premium amount using Fuzzy Inference of Sugeno Method is done. Based on the results and discussion have done previously, the conclusion is as follows. Three criteria are affecting the decision determination of premium value, namely the average income of the community, their expenditure monthly, and the flood zone area of community Bojongsoang and Baleendah District in Citarum River flow in 2016. Fuzzy Inference System (FIS) of the Sugeno method can be applied to determine the amount of premium in Bojongsoang and Baleendah District with the criteria of income, expenditure, and flood zone of residence. The implementation process in the FIS of the Sugeno method of determining the premium in passes four steps, defining the fuzzy variables, fuzzification, inference engine, and defuzzification. Based on the average income, expenditure, and flood zone area of the community of Bojongsoang and Baleendah District, the premium should be paid by every household is IDR 9,688.65 per month for Bojongsoang District community and IDR 10,256.27 per month for Baleendah District.

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