Journal of Theoretical and Applied Information Technology
31st March 2024. Vol.102. No 6

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

DISASTER CONTROL SYSTEM FOR LANDSLIDES USING SUGENO FUZZY ALGORITHM

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ABSTRACT

One of the geological phenomena known as landslides is the movement of rocks or soil of different kinds, such as when boulders fall or heaps of soil collide. Natural disasters like landslides cause a great deal of death and property damage, not just in Indonesia but all over the world. Landslide incidents typically result from a variety of causes. One of them is the idea that rivers and rainwater cause erosion. Science must therefore find a way to stop this landslide disaster before it happens and prevents people from losing their property and suffering fatalities. Thus, by making use of this system for controlling landslides. This study determines whether or not development on a passed hill or mountain is susceptible to landslides. where the Fuzzy Sugeno algorithm's computation yields the expected results of the process on this component research system tool.The first sensors are the MPU-6050, which can detect movement on the ground, the hygrometer sensors, which can detect soil moisture, and the wemos d1 r2, which can send messages to residents via Telegram bots and trigger a buzzer by sounding a relay.
Keywords: *Fuzzy Sugeno; Avalanche; System Control.*

1. INTRODUCTION

Natural disasters like landslides frequently happen as a result of shifting soil. One of the geological phenomena known as landslides is the movement of rocks or soil with different kinds and types, such as the falling of rocks or big groups of soil [1]. The high risk of landslides in the Aceh province area and Southeast Aceh Regency served as the impetus for this study. A landslide occurred on Sunday, the 12th of July, 2020 in Simpur village, Ketambe District, in the Southeast Aceh Regency area. This landslide disaster resulted in three severely damaged units (RB), four moderately damaged units (RS), and thirty severely damaged units (RR). According to information gathered from the local office, there are zero victims overall, comprising zero fatalities, zero hospitalized or seriously injured individuals, and zero thousand outpatients with minor injuries.

Fuzzy Sugeno permits a membership value to range from 0 to 1. That is, two values of Yes and No, Right and Wrong, or Good and Bad can coexist in a situation[2]. Fuzzy Sugeno is a theory that enables computers to mimic human intelligence, leading to the expectation that computers will be able to perform tasks that would require human intelligence. We can therefore conclude that fuzzy logic serves the purpose of mimicking human intelligence in order to perform a task and then applying it to a device, like cars or robots [3]. Complex mathematical equations for the object to be controlled are not necessary when using fuzzy logic [4]. The amount of inventory can be ascertained by applying Seneno's Fuzzy

Journal of Theoretical and Applied Information Technology
31st March 2024. Vol.102. No 6

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

method. Sugeno's Fuzzy Algorithm employs a fuzzy set of sets with monotonous membership

Additionally, this system makes use of the Internet of Things (IoT) to determine whether or not developments situated atop hills or mountains are susceptible to landslides [6]. This research has the potential to lessen the number of fatalities and property loss associated with this landslide disaster [7]. By focusing on the three primary components of IoT architecture—physical devices with IoT modules, Internet connection devices like wireless modems and routers, and cloud data centers as locations for databases and applications—the idea of IoT can be understood as being fairly straightforward [14]. And one way to create a more effective system is with smartphones running the Android operating system. In addition to being tools for messaging and communication, smartphones are packed with features that simplify a wide range of tasks for their users [15]. Since machines are now connected to the internet, or the Internet of Things, in the 4.0 era, a great deal of knowledge is required in the artificial intelligence era. It is crucial to employ artificial intelligence, whose performance draws from an expert's knowledge and experience and stores it in a computer that can evaluate, forecast, and resolve uncertainty [12]. Additionally, this chip's diverse IC-IC interface capabilities make it simple to connect or freely connect microcontrollers with additional built-in peripherals [16]. It can also represent linguistic meaning in the process of solving a problem by using the Fuzzy Set Mamdani (MFS) method [2].

The goal of this research is to develop a prototype system using fuzzy logic algorithms that can both monitor and regulate the occurrence of landslide hazards. The Wemos D1 R2 can send messages to residents using Telegram bots and can sound the Relay to sound the buzzer. The MPU-6050 sensor can detect movement on the ground, and the Hygrometer sensor can measure soil moisture. Additionally, the system can use Wemos' wifi to send messages to Telegram using ESP8266 components, and the user will receive a notification via the provided bot.

2. METHODS

A research method is a methodical approach to work that helps an activity accomplish its goal [8]. The Fuzzy Sugeno algorithm was used in the study to analyze the issues. Direct methods of gathering related research data include direct interviews with functions to represent every rule [5].

members of the Southeast Aceh community, observations, and citations of earlier studies in the field. This system's purpose is to identify movement on a cliff. First, the sensor measures soil movement through calculations utilizing fuzzy sets and the Sugeno method algorithm. It then analyzes the data to determine whether or not a mountain or slope can result in a landslide, saving and forwarding it to the user who entered the data [9][10]. In order to represent linguistic meaning when addressing a particular problem, it can also employ fuzzy methods [18]. additionally to construct a system with fuzzy-neural designed systems that function as fuzzy reasoning units by having input-output relationships[19]. Real-time classification is required to manage a variety of inputs and language issues [20].

2.1 Gathering of Data

Data on landslide-prone areas on Mount Lauser A in the Southeast Aceh region of Kabuaten Southeast Aceh, Aceh Province, were used in this study. When gathering data other than through interviews, two maps—soil movement, rainfall, and landslide vulnerability analysis—are consulted in order to make direct observations about the subject of the study. references to scientific studies as well. The degree of landslide proneness isdetermined by the ground movement and rain outpouring criteria, as shown in Figure 1 below.

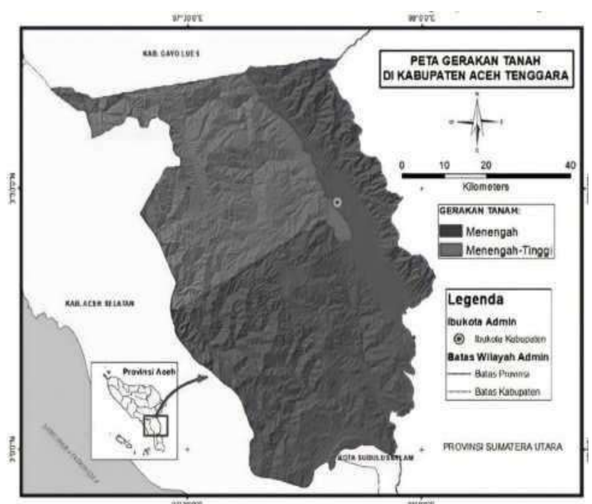


Figure 1: Map of Ground Movement

The Ministry of Energy and Mineral Resources has classified the land movement map of Southeast Aceh district into two subcategories:

medium high movement and medium movement. Sub-criteria then become score values, and these criteria eventually become weighted values [11].

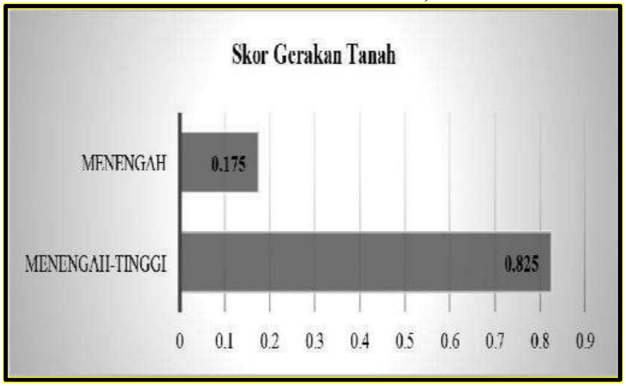


Figure 2: Graph of Rainfall Score Value

2.2 Algorithm for System

The Sugeno Fuzzy algorithm is the system algorithm that is employed. to examine data regarding the vulnerability of landslides, with a minimum of 0.100 (low) and a maximum of 0.600 (high). The expression for soil movement is 0-0.9, where ≤ 0.175 represents medium movement and ≥ 0.825 represents high movement.The range of values for the soil moisture level is 0-0.6, where <=042 denotes very low, 0.042-0.069 low, 0.069-0.138 medium, 0.138-0.267 high, and 0.487-0.6 very high. And these guidelines are in use:

1. R1 : If the soil movement is medium and the humidity is very low, then the level of landslide vulnerability is Low
2. R2 : If the soil movement is medium and low humidity, then the level of landslide vulnerability is High
3. R3 : If the soil movement is medium and soil moisture is moderate, then the level of landslide vulnerability is Low
4. R4 : If the movement of medium soil and soil inertia is high, then the level of landslide vulnerability is High

2.3 Fuzzification

Variable 1: Ground Movement

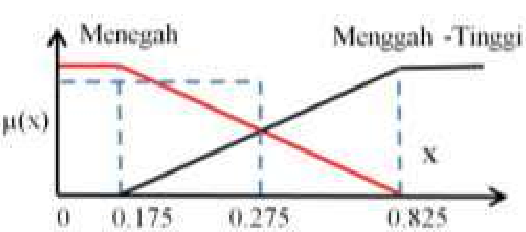


Figure 3: Chart of ground movement

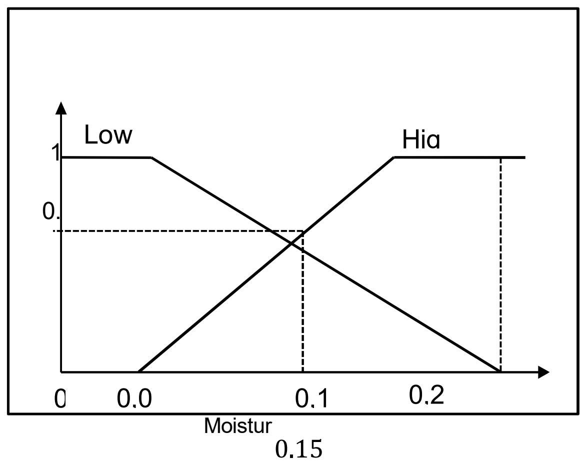
$$\mu\text{Medium}(x) = \begin{cases} 1 & x \leq 0.825 \\ \frac{0.825-x}{0.825-0.175}; & 0.175 \leq x \leq 0.825 \\ 0 & x \leq 0.175 \end{cases}$$

$$\mu\text{Medium-High}(x) = \begin{cases} 0 & x \leq 0.175 \\ \frac{x-0.175}{0.825-0.175}; & 0.175 \leq x \leq 0.825 \\ 1 & x \geq 0.825 \end{cases}$$

As for the degree to membering for soil movement = 0.275

$$\mu\text{Medium}(0.275) = \frac{0.825-0.275}{0.825-0.175} = \frac{0.55}{0.65} = 0.84$$

$$\mu\text{Medium-High}(0.275) = \frac{0.275-0.175}{0.825-0.175} = \frac{0.1}{0.65} =$$



Variable 2: Soil moisture

Figure 4: Graph of Soil Moisture

$$\mu\text{Low}(x) = \begin{cases} 1 & x \leq 0.069 \\ \frac{0.267-x}{0.267-0.069}; & 0.069 \leq x \leq 0.267 \\ 0 & x \geq 0{,}267 \end{cases}$$

$$\mu\text{High}(x) = \begin{cases} 0 & x \leq 0.069 \\ \frac{x-0.069}{0.267-0.069}; \frac{0.487-x}{0.487-0.267} & 0.069 \leq x \leq 0.267 \\ 1 & x \geq 0.267 \end{cases}$$

Regarding the level of participation for soil moisture = 0.157

$$\mu\text{Low}(0.157) = \frac{0.267-0{,}157}{0.267-0.069} = \frac{0.11}{0{,}198} = 0{,}55$$

$$\mu\text{High}(0.157) = \frac{0.157-0.069}{0.267-0.069} = \frac{0.088}{0.198} = 0{,}44$$

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Variable 3: Susceptibility to Landslides

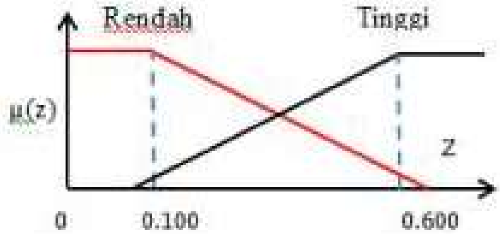


Figure 5: Graph of Avalanche Vulnerability

$$\mu Low\ (z) = \begin{cases} 1 & z \leq 0.600 \\ \frac{0.600-z}{0.600-0.100}; & 0.100 \leq x \leq 0.600 \\ 0 & x \geq 0.600 \end{cases}$$

$$\mu High\ (z) = \begin{cases} 0 & z \leq 0.100 \\ \frac{z-0.100}{0.600-0.100}; & 0.100 \leq x \leq 0.600 \\ 1 & z \geq 0.600 \end{cases}$$

2.4 Inferense

After getting the Rule :

R1 : If soil movement is medium and humidity is low, then the level of landslide vulnerability is Low

α – Predicate 1 = μ Medium(x) ∩ μ Low(x)
= minimum(μMedium(0.84) ; μLow (0, 55))
= minimum(0,84;0,55)
= 0,55

Value Z_1= $\frac{0.600-z1}{0.600-0.100}$=0,25; 0,25 =0,6-$Z_1$, So that Z_1=0.35

R2 : If soil movement is medium and humidity is high, then the level of landslide vulnerability is High

α – Predicate 2 = μMedium(x) ∩ μHigh(x)
= minimum(μMenegah(0.84) ; μHigh(0. 44))
= minimum(0.84;0,44)
= 0,44

Value Z_2= $\frac{Z2-0.100}{0.600-0.100}$=0,44; 0,22 =$Z_2$-0,1 So that Z_2=0.32

R3 : If soil movement is Medium-High and soil moisture is low, then the level of landslide vulnerability is Low

α – Predicate 3 = μMedium-High(x) ∩ μLow(x)
= minimum(μMedium-High(0.15) ; μLow(0. 55))
= minimum(0.15;0.55)
= 0.15

Value Z_3= $\frac{0.600-z}{0.600-0.100}$=0,15; 0,075 =0,6-$Z_3$, So that Z_3=0.525

R4 : if the soil movement is Medium-High and the soil inertia is High, then the level of landslide vulnerability is High

α – Predicate 4 = μMedium-High(x) ∩ μ High (x)
= minimum(μMedium(0.15) ; μ High (0. 44))
= minimum(0.15)
= 0.15

Value Z_4= $\frac{Z4-0.100}{0.600-0.100}$=0,15; 0,075 =$Z_4$-0,1 So that Z_4=0.175

2.5 Defuzzification

Following the acquisition of the inference rule results, the average value is computed as follows :

$$Z^* = \frac{\sum_i^n apredikat * Z_i}{\sum_i^n apredikat_i}$$

$$Z * = \frac{(0{,}35\ *\ 0.55) + (0{,}32 * 0.44) + (0.525 * 0.15) + (0.175 * 0.15)}{(0{,}55 + 0{,}44 + 0.15 + 0{,}15)}$$

$$z * = \frac{0.439}{1{,}29} = \ 0{,}34$$

Evaluated in accordance with the spectrum of landslide susceptibility levels determined by measuring soil movement and moisture content. in order for the value of the computation results to be higher than southeast aceh's landslide vulnerability level. in all, 0.34.

3. RESULTS AND DISCUSSIONS

3.1 Implementing the System

The stage of system implementation involves ensuring that the system functions as intended and providing a description for each image that is taken. System analysis, design, design of the smallest system components, and system creation are the first steps in this implementation. following the design and implementation of the new systemDiscussion is the basic explanation, relationship, and generalization demonstrated by the results. The description answers a research

Journal of Theoretical and Applied Information Technology
31st March 2024. Vol.102. No 6

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

question. If there are dubious results, point them out objectively.

3.2 ***Range of Wemos D1-R2***

Wemos has multiple inputs and outputs that serve as ports to link the various components.

The page size is A4 (210mm x 297mm). The margin is 25 mm from top to bottom, left and right. Two columns with a column spacing of 0.4pt are displayed.

Figure 5: Display Wemos D1-R2.

3.3 I2c Hygrometer for Soil Moisture

As shown in figure 6 below, the I2c Soil Moisture Hygrometer serves as a connector for the Hygrometer sensor to the Wemos D1-R2 and is part of the Landslide Disaster Control System.

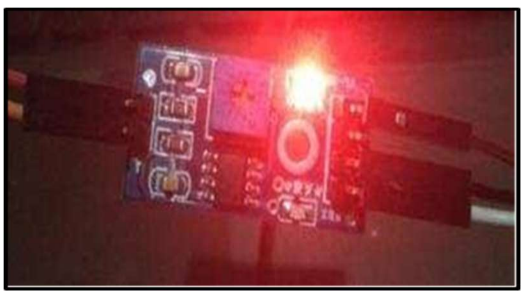


Figure 6: Linking Wemos To A Hygrometer Using An I2c Display

Figure 7: Soil Moisture Is Displayed By The I2c Hygrometer.

The IoT-based Landslide Disaster Control System uses the Wemos D1-R2 system's component display as both a controller and wifi.

3.5 Range of Soil Moisture Higrometer

The Hygrometer sensor in the Landslide Disaster Control System measures the moisture content of the soil.

Figure 8: Display Of The Soil Moisture Hygrometer Sensor

3.6 Gyroscope MPU-6050 Circuit

One of the input components on the scaffolding of this system is the MPU-6050 Gyroscope sensor, which measures movement in landslides.

Figure 9 : Gyroscope Sensor Display Mpu-6050

3.7 Circuit of Relays

A series of relay components in the Landslide Disaster Control System with the IoT-based Sugeno Fuzzy method work together to sound a 5 volt buzzer as a warning of impending danger.

Figure 10: View From Ralay

Journal of Theoretical and Applied Information Technology
31st March 2024. Vol.102. No 6

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

3.8 Series of Buzzers

Figure 11: Display Of Buzzers

3.9 System Testing

Testing the Avalanche Disaster Control system is done to find out how well it works overall. The primary components and the entire system are tested first. After the parts and components are installed as they are manufactured, system testing is done.

The MPU-6050, Wemos, and Hygrometer Sensor test results were successful and met expectations. as demonstrated in the image below

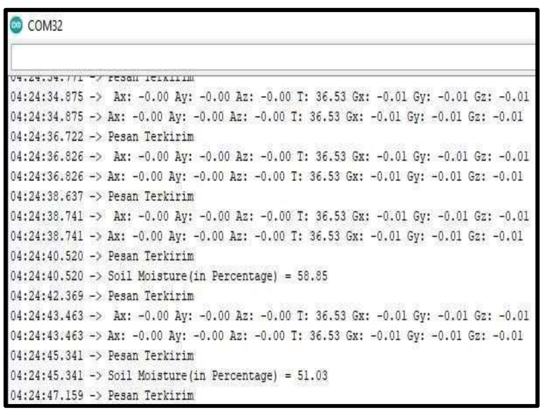


Figure 12: Arduino IDE Motinor Series Display

Wemos delivers messages to users via the Telegram bot in the test results as anticipated. where the user will receive notifications from the bot. The test's outcomes are displayed in figure 13 below

A number of buzzers in this control system serve as a warning that a landslide is possible

Figure 13: A Bot Alerting The User To A Message

4. CONCLUSION

The following are the study's conclusions based on the problem formula's predicted outcomes and the research's findings:

1. The MPU-6050 sensor, hygrometer sensor, Wemos D1 R2, relay, buzzer, and telegram are required components for designing a landslide disaster control system using Sugeno's fuzzy algorithm.
2. The Landslide Disaster Control system's operation, beginning with the two sensors that use the fuzzy sugeno method—which has been computed during analysis—to detect movement and moisture in the soil. It will be sent to Wemos D1 R2 if, after the sensor detects movement and soil moisture, the algorithm using the pre-set fuzzy sugeno can result in a landslide disaster. Following processing by Wemos, D1 R2 will instruct the relay to sound the buzzer and send a message to Telegram via the built-in ESP8266 wifi component. Following this, the user will receive a notification message via the provided bot.
3. Sugeno's fuzzy algorithm computations yielded the expected results for this component research system tool. The first sensors are the MPU-6050, which can detect movement on the ground, the hygrometer sensors, which can detect soil moisture, and the wemos d1 r2, which can send messages to residents via Telegram bots and trigger a buzzer by sounding a relay.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

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