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Flash Flood Early Warning System Using Mini PC Case Study: *Mount Nago* Water Reservoir

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***Abstract*— The high rainfall that has poured into the city of Padang has made the Mount Nago dam to overflow and resulted in flash floods. Observation of weather and water level of the dam is very important to do to estimate the possibility of the occurrence of a flash flood. This study aims to build an early warning system by utilizing Raspberry Pi as a control center. Environmental weather reading with temperature, humidity and wind speed parameters is carried out by Automatic Weather System (AWS) which uses DHT11 sensor and cup propeller. Weather reading data is processed using fuzzy logic to get the categories of 'sunny', 'cloudy' weather, 'light rain' and 'heavy rain'. The weather category and the water level of the dam which are read through the ultrasonic sensor are reprocessed to get 'safe', 'standby', 'warning' and 'danger (flash flood) information. The results show that AWS works well, which is 80%, and the flash flood early warning system can work, with a success rate of 70%.**

Keywords*— *Flood, AWS, Raspberry Pi, Python, Ultrasonic

I. Introduction

Flash floods are a disaster that often occurs in the city of Padang, especially in the river flowing from the top of the hill. Flash floods occur so fast and come suddenly so that people are not ready to deal with it. In plain view, the signs that flash floods will occur are when heavy rain and strong winds occur, the river flow appears to be receding due to landslide material held upstream or along the river flow.

After that, the water will overflow quickly and hit anything in front of it. At that time the color of the river water turned cloudy because the water was mixed with soil and mud, and smelled. This flood was accompanied by a roar from the direction of the river flow. All of these are signs that water, mud, rocks and tree trunks are moving in the flow of the river [1]. Residents in the vicinity of the river flow are alarmed and continue to monitor the water level through meter sticks which are installed on the dam. They fear flash floods occur. When the water flows in the river is quite high, monitoring the water level in the dam is difficult to do, especially if the dam is broken. The flow of water will then flood agricultural areas and people's housing.

Flash floods are floods that come suddenly with a reasonably large water discharge and are caused by the water being blocked upstream of the river [2]. The problem is no early system is available in the field to estimate the possibility of the occurrence of a flash flood. Previous related research [3] discusses the effects of weather on flood early warning systems. Most research on flood early warning uses data mining using a wireless sensor network [4]. This study uses data mining with a C4.5 algorithm to produce decision trees.

Furthermore, research using ultrasonic sensors as a detector of water level, buzzer and SMS (short message service) as a flood warning tool [5]. The three studies have limitations and have not been able to estimate the possibility of whether there will be flash floods or not at the location flowing by the river. Referring to the three previous research, the researchers conducted a research on a flash flood early warning system which is based on the weather data reading by the Automatic Weather System (AWS)[6][7] using DHT11 sensor components[8][9], rotary encoder[10], optocoupler and cup propellers[11] and water level gauges on dams using sensors ultrasonic[12][13] controlled by Raspberry Pi[14][15][16]. The weather reading data by AWS is then processed using fuzzy logic method [17][18] which is used as a reference to get the weather category which is then processed together with the ultrasonic sensor reading data to obtain information on whether or not a discharge will occur.

II. METHODOLOGY

The research of this flash flood early warning system uses several stages which begin with studying the literature related to the problem. The stages of the research can be seen in Figure 1 below.

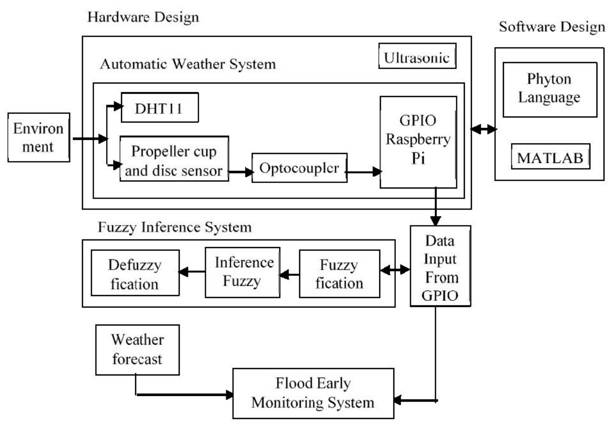

Fig 1. Block process of the flood early warning system

System design consists of hardware design and software design. Hardware design consists of two parts, namely Automatic Weather System (AWS) and Ultrasonic sensor. AWS is built using DHT11 sensor components, rotary encoder, optocoupler, and propeller cup. The DHT11 sensor is used to measure temperature and relative humidity, the rotary encoder to read the rotation of the sensor dish that is paired with the cup propeller to measure wind speed, and the optocoupler circuit as a signal reader from the disk rotation. While the JSN SR04T ultrasonic sensor is used to measure the water level. All components are connected with GPIO Raspberry Pi. Raspberry Pi functions as a processor for monitoring and early warning systems on dams.

A. Designing FIS weather forecasts

The FIS design is the brain of AWS to make decisions about weather forecasts of variable temperature, relative humidity, and wind speed. The variable is then processed in several stages, namely fuzzification, fuzzy inference rule and defuzzification using the centroid method. The results of weather processing are used to determine four categories of weather forecasts which are sunny, cloudy, light rain and heavy rain as shown in Figure 2 below.

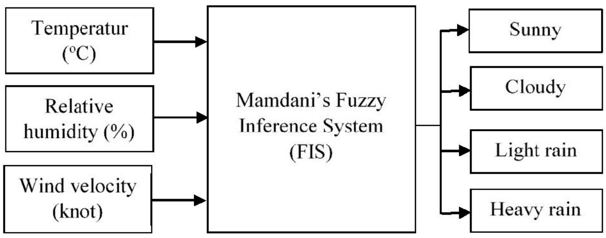

Fig 2. FIS design weather forecast

B. Fuzzy Logic Modeling

The three weather history data variables from BMKG are grouped with Fuzzy Clustering C-mean algorithm (FCM) using Matlab. The output of the FCM is a row of cluster centers and several degrees of membership for each data. By clustering, membership functions can be determined from each weather variable, grouped into several clusters, to determine the fuzzy set (Table 1). Furthermore, fuzzy inference is constructed in the form of a fuzzy logic rule base from the BMKG historical data pattern.

TABLE 1. Grouping of fuzzy weather variables

Weather variables	Fuzzy set
temperature (°c)	low
	medium
	high
humidity (%)	low
	medium
	high
wind velocity (knot)	low
	medium
	high

The membership function used in each weather variable is a Gaussian curve, because it is suitable for continuous data and natural data such as weather.

C. Fuzzification

Fuzzification is done to map weather variable input values into fuzzy set forms. The membership function of the weather variable is obtained from the FCM results of BMKG history data, with a temperature range of 22.6 - 32.5 °C, humidity 51-99% and wind speed between 0 - 20.22 knots. The output from FIS is a weather value that has been categorized into four types, that is 'sunny', 'cloudy', 'light rain' and 'heavy rain'. The following is the fuzzy set of each input variable, namely table 2 variable temperature function, table 3 membership function variable relative humidity and table 4 variable speed wind membership function.

TABLE 2. Variable temperature membership function

No	Input name	Description	Deviation standard	Average
1	temp_lo	low temperature	2.33	24.44
2	temp_av	moderate temperature	2.33	26.71
3	temp_hi	high temperature	2.33	29.72

TABLE 3. The membership function is variable relative humidity

No	Input name	Description	Deviation standard	Average
1	humi_lo	low humidity	10.54	68.35
2	humi_av	moderate humidity	10.54	82.57
3	humi_hi	hight humidity	10.54	92.25

TABLE 4. Variable wind speed membership function

No	Input name	Description	Deviation standard	Average
1	winv_lo	low wind velocity	2.39	2.12
2	winv_av	medium wind velocity	2.39	4.73
3	winv_hi	high wind velocity	2.39	8.45

D. Fuzzy Inference

In this study, fuzzy inference uses AND implications (MIN operators) because all weather variables are mutually influential in determining weather forecasts. The following are fuzzy inferences to determine weather forecasts as shown in Figure 3 below.

if (temp is Lo) and (humi is Lo) and (wind is Lo) then the weather is Bright)
If (temp is Lo) and (humi is Lo) and (wind is Av) then the weather is Light_Rain)
if (temp is Lo) and (humi is Lo) and (wind is Hi) then the weather is Heavy_Rain)
if (temp is Lo) and (humi is Av) and (wind is Lo) then the weather is Cloudy)
..
etc.

Fig 3. Fuzzy weather inference

E. Defuzzification

Defuzzification is the stage of changing the fuzzy value into the form of a strict value (crisp). Here, the defuzzification process uses the centroid method. The crisp solution is obtained by taking the center point (Z_o) of the fuzzy region. The defuzzification process in AWS uses continuous variables with equation (1)

$$Z_o = \frac{\int \mu_c .(z).zdz}{\int \mu_c .(z)dz} \quad (1)$$

where:
Z_o is the center point; μ_c is membership degree; z is crisp value

F. Information on Flash Flood Early Warning

Early warning information generated is grouped into four categories, namely 'safe', 'standby', 'warning' and 'danger (flash flood)'. The information category is generated by reading the value of the weather change variable (table 5) and the water level variable from the reading of the JSN SR04T ultrasonic sensor on the dam as shown in table 6. The alarm will be active if the resulting information category is at 'danger' and 'warning'.

TABLE 5. The membership function of weather variables

No	Weather category	Value
1	sunny	0< zo <25
2	cloudy	25< zo <50
3	light rain	50< zo <75
4	heavy rain	75< zo <100

TABLE 6. Water level variable membership function

No	Water level (h)	Water depth (cm)
1	low	< 100
2	medium	101 < h < 150
3	high	151 < h < 200
4	very high	>= 200

From the two parameters in Table 5 and Table 6, the status of flash flood forecasts is determined by using the rule base which is grouped as the logic table (Table 7).

TABLE 7. Logic table for flood forecasting

No	Water level (h)	Weather	Category information	Alarm status
1	low	Sunny	secure	off
		cloudy	secure	off
		light rain	secure	off
		heavy rain	standby	off
2	medium	Sunny	standby	off
		cloudy	standby	off
		light rain	standby	off
		heavy rain	warning	on
3	high	Sunny	warning	on
		cloudy	warning	on
		light rain	warning	on
		heavy rain	danger (flash floods)	on
4	very high	Sunny	danger (flash floods)	on
		Cloudy	danger (flash floods)	on
		light rain	danger (flash floods)	on
		heavy rain	danger (flash floods)	on

III. RESULTS AND DISCUSSION

The AWS system built is placed in an open space at a location about six meters above the dam. At the bottom, there is a waterproof box that contains board of ultrasonic sensors and sirens as a flood early warning alarm. In detail the results of testing hardware and software are as follows:

A. Testing and Analysis of Temperature Measurement by DHT11

Sensor DHT11 sensor testing is done by comparing the results of temperature measurements on DHT11 with a digital thermometer, the K-type thermocouple TM902C thermometer which has a better accuracy value + (0.75% + 1 ° C) with DHT11 + 2 ° C. Figure 4 shows a graph of the results of temperature testing on DHT11 sensors with Thermocouple TM902C.

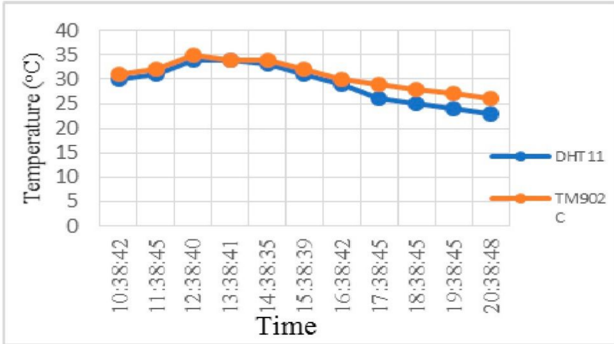

Fig 4. The DHT11 temperature reading comparison chart and TM902C Thermocouple

From Figure 4 above it can be seen that the results of the temperature reading test by the DHT11 sensor with TM902C Thermocouple have almost the same accuracy during the day, but the night has a slight difference in value. This difference is due to the DHT11 sensor reading is less accurate than TM902C.

B. Testing and Analysis of Relative Humidity Measurement on DHT11 Sensors

The results of measurements of relative humidity by the DHT11 sensor are compared with that by the hygrometers. The graph of the measurement of relative humidity by DHT11 and hygrometer sensors can be seen in Figure 5 which show the difference reading between DHT11 relative humidity and hygrometer.

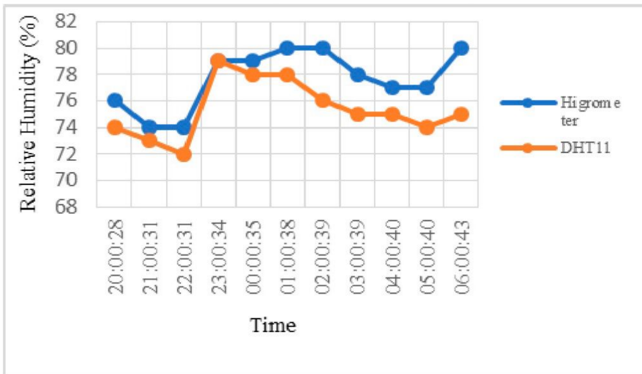

Fig 5. DHT11 sensor and hygrometer measurement chart

This difference occurs because in measuring the relative humidity value the DHT11 specification has an accuracy of + 5% RH. Besides that, the DHT11 sensor is better at reading relative humidity at night.

C. Testing and Analysis of Wind Speed Gauge

The rotary encoder reads the rotation of the sensor disk paired with the cup propeller on AWS. The output of the optocoupler sensor is the average pulse value from the rotation of the sensor disk. To change the pulse number to the wind speed, the calibration process is carried out on a motorcycle, by comparing the value of the speed of the motorbike that moves with the pulse read by the optocoupler from the rotation of the sensor disk. To get more accurate results, a digital GPS had a speedometer application on a smartphone, with a unit of measurement speed of mile per hour (mph). Table 8 shows the reading of wind speed values on vehicles with an average pulse value at AWS.

TABLE 8. Calibrating value of wind speed on the vehicle and the average pulse value on AWS

No	Vehicle speed on a digital speedometer (mph)	Number of pulses on AWS
1	5	22
2	10	52
3	15	82
4	20	112
5	25	142

Here it can be seen that by varying the vehicle speed by five mph, it is obtained a value that has good linearity for each change in speed. The average pulse value test results on AWS rose to 30 pulses per test. Based on the tests that have been done, the sensitivity of the wind speed measuring device can be calculated by the formula:

$$y=0.1667x + 1.3333 \quad (2)$$

where:
y is the speedometer speed (mph), and x is the average pulse on AWS

So, the sensitivity of the wind speed gauge at AWS is six pulses/mph. Figure 6 is a comparison graph of the measurement of wind speed on a digital speedometer with an average pulse on AWS based on Table 8. From the results of the comparison of wind speed values on vehicles with an average pulse value in AWS, the linear regression equation is obtained:

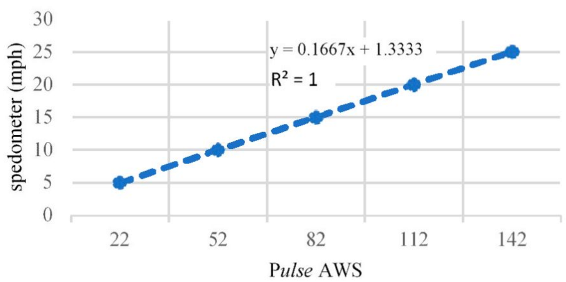

Fig 6. Graph comparison of digital speedometer speed measurements and pulse averages on AWS

Equation (2) shows that the value of y is the speed of the speedometer (in mph) and the value of x is the average pulse on AWS. This equation is used to change the pulse value to the value of the wind speed in mph which is then converted into units of knots with the formula:

$$1\ mph = 0.868976242\ knot \quad (3)$$

The test on wind speed measurements on AWS shows that the minimum wind speed value that can be measured by AWS from an increase in speed of 0 knots (called the threshold) is equal to 1.3005 knots. This means that there is no wind speed value which is measured by AWS when the wind speed is less than 1.3005 knots. The smallest value of change from wind speed or resolution value can be known by comparing the number of pulses with the value of wind speed based on the linear regression equation (equation (2)). Thus, the value of the change in wind speed of each pulse increase can be calculated, as shown in Table 9 below.

TABLE 9. Comparison of pulse numbers and wind speed and changes in the speed of one pulse increase

Number of pulses	Wind velocity/ V(mph)	changes in wind speed /ΔV(mph)	Wind velocity / V(knot)	changes in wind speed / ΔV(knot)
1	1.4967	-	1.3005	-
2	1.6634	0.1667	1.4454	0.1449
3	1.8301	0.1667	1.5903	0.1449
4	1.9968	0.1667	1.7351	0.1449
5	2.1635	0.1667	1.8800	0.1449

From the Table 9 above it was found that the resolution value of the wind speed measurement at AWS was 0.1667 mph, or equal to 0.1449 knots.

D. Testing and Analysis of Weather Forecast on AWS indication

AWS is placed in an open space with a height of six meters above the dam. Table 10 shows the results of measurements of weather forecasts by AWS on Friday, October 17, 2017, which were updated ten times per hour. The test results show that AWS stated "in accordance" with real weather or actual weather as much as eight times (80%) and that is not appropriate as much as two times (20%). The incompatibility of AWS decisions with actual weather is caused by the influence of various things, such as disturbances in reading from the location, AWS placement that is not too high and the location of the dam at the foot of the hill.

E. Testing and Analysis of Water Levels

Testing of water level reading on the dam is carried out by the JSN SR04T ultrasonic sensor. The sensor reading results are compared to the measuring line of the dam located on the wall of the dam that has been marked with a paint scratch. The maximum height of the dam line is 3 meters.

The calculation of the water level in the dam is carried out using the equation (1), where the dam height from the base of the dam is 315 cm. The water level calculation is based on the height of the dam minus the reading distance of the JSN SR04T sensor. Testing of ultrasonic sensor readings from 16:48:40 to 19:03:53, the data of which was updated every 15 minutes, then compared with the measuring line on the dam, carried out ten times. The measurement results are shown in figure 7.

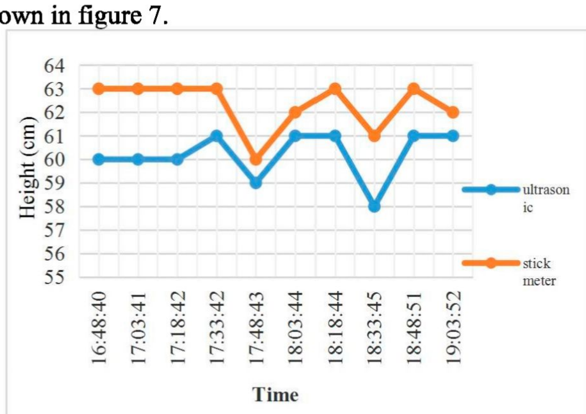

Fig 7. Ultrasonic sensor reading graph and dam measuring line

F. Testing and Analysis of Flash Floods Early Warning System

This test is the final stage of all system testing. The test results provide information in the form of four standby categories, namely 'safe', 'standby', 'warning' and 'danger (flash flood)'. The siren as an alarm will be activated if the standby category indicates 'warning' or 'danger (flash flood)'. From 10 tests on Monday, November 10, 2017 from 16:48:40 - 19:03:52 that was updated every 15 minutes resulted 3 times (30%) not suitable, namely at 18:18:44, 18:48:51 and 19:03:52. The results of reading the flash flood early warning system in Python Shell can be seen in Figure 8, and the summary of the test is in Table 11.

```
Finish update: Friday 11/12/2017 18:18:44
Water level: Medium
Weather: Cloudy
Alarm: off
*************
Finish update: Sunday 11/12/2017 18:33:45
Water level: Medium
Weather: Light Rain
Alarm: off
*************
Finish update: Sunday 11/12/2017 18:48:51
Water level: Medium
Weather: Heavy Rain
Alarm: on
*************
Finish update: Sunday 11/12/2017 19:03:52
Water level: Height
Weather: Heavy Rain
Alarm: off
```

Fig 8. Results of reading the flash flood early warning system

TABLE 11. Recapitulation of the results of reading the flash floods early warning system

No	Time	Early warning system forecast variables		Category information	Alarm status	Information
		Water level (cm)	Weather			
1	16:48:40	low	cloudy	secure	off	appropriate
2	17:03:41	low	Bright	secure	off	appropriate
3	17:18:42	low	Bright	secure	off	appropriate
4	17:33:42	low	Bright	secure	off	appropriate
5	17:48:43	low	Bright	secure	off	appropriate
6	18:03:44	low	cloudy	secure	off	appropriate
7	18:18:44	medium	cloudy	secure	off	not appropriate
8	18:33:45	medium	light rain	standby	off	appropriate
9	18:48:51	medium	heavy rain	standby	on	not appropriate
10	19:03:52	height	heavy rain	danger (flash floods)	off	not appropriate

The incompatibility of the information generated by the system is caused when the water is getting higher, the read distance of the water surface with the ultrasonic sensor is getting closer, so the accuracy of the reading decreases. Besides that, the existence of extreme weather changes around the location at the time of testing also affects the sensor reading.

IV. CONCLUSION

Based on several testing on the components and the flash flood early warning system at the Mount Nago dam, Pauh District, Padang City, it can be concluded that the success rate of environmental weather reading by the Automatic Weather System (AWS) is 80% and the flash flood early warning system performs satisfactorily, that is 70%. With the success of this system, it is expected that the system can be produced and developed by the needs to answer the problems in the field.

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REFERENCES

[1] LIPI, Four Characteristics of Flood Arrival Geo technology Research Center.

[2] Hartono, Geography of Exploring the Earth and Universe, Citra Praya, Bandung, 2007

[3] Alvian, Advin, Early Warning System Facing Extreme Climate, Journal of Land Resources, Vol. 10 No. 2, December 2016; 79-90

[4] Putra, Roni, Design, and Implementation of Flood Early Warning Using Data Mining with Wireless Sensor Network, National Journal of Electrical Engineering, 5 (2), 2016, 181-191.

[5] Sumarno, Flood Early Warning System with ATmega 16 Microcontroller Based on Buzzer and Short Message Service (SMS), Universitas of Kalimantan, Pontianak, 2013

[6] World Meteorological Organization, Guide to Meteorological Instruments and Methods of Observation, Seventh Edition: Geneva, 2008

[7] National Aeronautics and Space Institute, Automatic Weather Station.

[8] DHT11, DHT11 - Humidity and Temperature Sensor, 2012.

[9] DHT 11 Humidity & Temperature Sensor Mikrotik DHT11 Datasheet.

[10] Society of Robots, Sensors-Robot Encoder (Slot, Rotary, Linear).

[11] Gunawan, Hanapi. Electronic Principles, Erlangga: Jakarta, 1992

[12] Ikuo Ihara, Ultrasonic Sensing: Fundamentals and Its Applications to Nondestructive Evaluation, Nagaoka University of Technology

[13] Factory Automation, Ultrasonic Sensors, Courtesy of Steven Engineering, Inc. 230 Ryan Way, South San Francisco

[14] Richardson, M, and S. Wallace, Getting Started With Raspberry Pi. O'Reilly Media, Inc., USA, 2013

[15] Rakhman, Edi, Raspberry Pi, Small Microcontroller, Versatile, Andi, Yogyakarta, 2014

[16] Yendri, Dodon, Smart Home Security and Control System Based on Android, Journal of Information Technology and Computer Engineering, Volume 2, Number 01, 2018, ISSN (Online) 2599-1663

[17] S. N. Sivanandam, S. Sumathi and S. N. Deepa, Introduction to Fuzzy Logic using MATLAB, Springer-Verlag Berlin Heidelberg, 2007

[18] Rebbi B, Julianto, Design of Automatic Tank Robot Detection Barrier Detection with Fuzzy Logic Control, Journal of Information Technology and Computer Engineering, Volume 2, Number 01, 2018, ISSN (Online) 2599-1663

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