Design of Windstorm Disaster Early Warning System based on IoT and Hall Effect Sensor in the Critical Area Location

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Keywords: Windstorm, Critical, Warning, IoT, Quickly.

Abstract: One of the biggest natural disasters in Banyuwangi is windstorm and it had brought in loss many property and life. However, the handling information of windstorm to the people in Banyuwangi still uses conventional way and it made warning information late in people. So they didn't have time to prepare and protect their property or life from windstorm. Therefore it is needed a system that can provide windstorm information quickly, accurately and widely. In this research, it was designed an early warning system (EWS) of windstorm by placing sensors in the critical locations. The placing of sensor in the right place made the windstorm detections more accurate. This research also used IoT technology, web site and android application to inform the wind speed, direction and warning notification quickly.

1 INTRODUCTION

Indonesia is a tropical country with islands and waters. Besides that Indonesia also have unique geographic position between two continents Asian - Australia and two ocean Indian - Pacific. Thus, the territory of Indonesia is in a cross position, which has significance in relation to climate and economy (Nisa, 2014). That position also influence to the Indonesian atmosphere which the changing of Indonesian atmosphere is caused by ITCZ (Inter Tropic Convergence Zone), ENSO (El Nino Sothern Oscillation) and MJO (Madden Jullian Oscillation. The changes in the atmosphere will bring climate change, weather and wind in the territory of Indonesia (BNPB, 2017).

The extreme change of climate, weather and wind will bring disaster and one of the most frequent disasters in Indonesia is windstorm. The windstorm disaster brought great destruction and one of the towns that was often hit by a windstorm disaster was Banyuwangi. The disaster trend in Banyuwangi also increase especially windstorm as shown in Figure 1.

The disaster management is very important but so far in Indonesia majority of disaster management still use traditional way. It is also in Banyuwangi, east Java, Indonesia, the disaster management still focused on the disaster impact (Yuliandoko et al., 2019).

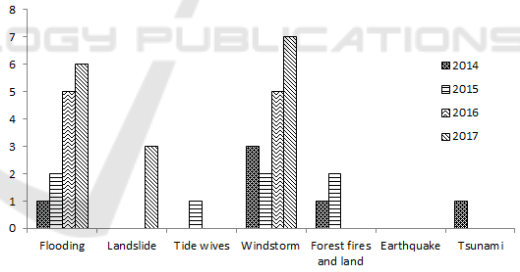

Figure 1: Disaster Trend in Banyuwangi (Hashiguchi et al., 2013).

One of important aspect on the disaster management is mitigation. In the mitigation there is early warning system as a critical life saving tool for floods, droughts, windstorm and other hazards. The effective Early warning system (EWS) contains four component (1) detection, monitoring and fore-casting the hazards; (2) analysis of risks involved; (3) dissemination of timely and authoritative warnings; and (4) activation of emergency preparedness and response plans (World, 2009). Because It is very useful for human life so it is needed to make any research and improvement on EWS. Research on EWS in Indonesia is still rare

Yuliandoko, H., Arief Wardhany, V., Subono, ., Hadi Pramono, S. and Siwindarto, P.
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DOI: 10.5220/0010962600003260
In *Proceedings of the 4th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2021)*, pages 1217-1224
ISBN: 978-989-758-615-6; ISSN: 2975-8246

especially on the small city, and the purpose of this research is to develop detection and monitoring windstorm by using technology IoT with reposition windstorm sensor on the critical location in Banyuwangi city.

Research on web base information of natural hazard in Aceh province was done by Nasaruddin, Khairul Muhadi, M. Dirmansyah and Dedi Yuliansyah. Their research made a conceptual design and the development of prototype for ANHIS (Aceh Natural Hazards Information System). The main purpose of ANHIS was to visualize many natural hazards maps and disseminate information of the hazardous areas for disaster agencies, researchers and communities in order to help them act on warning issue (Munadi et al., 2011). There are many kind of EWS due to the purpose of the detection of hazard, in the "Development of an operational coastal flooding early warning system", researcher made an early warning system to mitigate the loss of life and property from coastal flooding. The focus of this research to develop a coastal flooding warning system by integrating existing sea-state monitoring technology, numerical ocean forecasting models, historical database and experiences (Doong et al., 2012). Many EWS research on flooding detections, one of that is "Integration Method of Local-global SVR and Parallel Time Variant PSO in Water Level Forecasting for Flood Early Warning System". The proposed integration method of Parallel Time Variant PSO (PTVPSO) and Local-Glob al Support Vector Regression (SVR) is used to forecast water level. Implementation in this study combine SVR as regression method for forecast the water level, Local- Global concept take the role for the minimization for the computing time, while PTVPSO used in the SVR to obtain maximum performance and higher accurate result by optimize the parameters of SVR (Soebroto et al., 2018). Research on flooding detection also can be done trough monitoring of DAM water level and velocity of water. By monitoring these parameters can get information that the flood is happening. The data from sensor will send to smart phone android by using microcontroller ESP8266 (Yuliandoko et al., 2017). So the EWS today also use smart technology to spread the information to the people with more accurate and quickly.

Development of information technology after computer and internet is Internet of Things (IoT) (Bing, 2014). Today the application of IoT is very wide and interesting, because by using IoT can connect all goods with internet through information sensing device. This ability will help people to control or monitor other places via the internet. Therefore the application of IoT in the disaster management will be very useful for human being. This research also use IoT to send data of hazard especially windstorm speed, direction and level of danger to the people. By using this system the people will get a danger notification to their smart phone so they can prepare themselves from danger of windstorm disaster. This system also supported by web and android application to inform the disaster notification. To make accurate the windstorm data, sensors are placed in critical and potential of windstorm occur in Banyuwangi area.

2 RESEARCH METHOD

2.1 Research Steps

Research of "Windstorm Disaster Early Warning System on Critical Area Detection Method by Using IoT Technology" is done on the several step:

- Building the windstorm sensor detections
  Design of sensor detections has relation with flow of detection and accuracy of detections. In this research was made to be able to detect windstorm speed, windstorm direction and rainfall. After detect speed and direction this system will make a classification of hazard level of windstorm.
- Web and android based.
  This system also use web and android based to inform the measurement of sensor to the people. The advantages of this system are easy to monitor by people by using android application.
- Classify of the critical location windstorm disaster in Banyuwangi
  The critical location is very important to make an accurate detection with early warning system. This critical location based on BNSP (National Board for Disaster Management) Banyuwangi district data.
- Experiments result
  After all of system connected and running well, the experiments was done on the State Polytechnic of Banyuwangi LAB to make sure that the system can be implemented in the real condition.

2.2 Accident Area Mapping

Banyuwangi consists of 25 sub-districts with different characteristic of geographic. Although in some sub-districts accidents often occur due to strong wind. The accident was usually in the form of fallen trees, damaged agricultural land or damaged houses. Based on BNPB (National Board for Disaster Management) Banyuwangi district, there were four sub-districts had high frequency of accident.

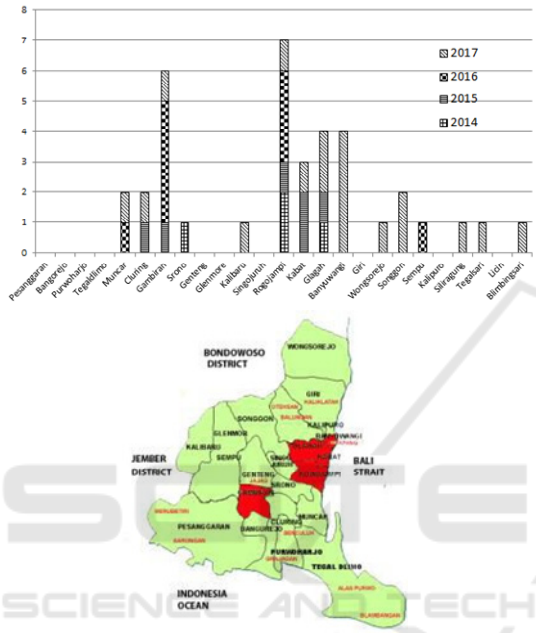


Figure 2: Accident Area Mapping in Banyuwangi (Bencana, 2015).

Refer to Figure 2, Sub-Districts Gambiran, Rogojampi, Banyuwangi and Glagah had highest frequency windstorm occur. Therefore these area become critical area detection of windstorm in Banyuwangi. This localization of area detection was very important because these areas had great potential for windstorm events in the region each year. The critical location will be the location of windstorm disaster sensor.

2.3 Disaster Warning System Propose

The most important in the warning system is fast and accurate information. If the people get an early accurate information, they can prepare to safe their live or property. In the BNSP Banyuwangi District have a mechanism to inform windstorm disaster to the people as shown in Figure 3, however the mechanism is too complicated and it can cause the delivery of late information to the people.

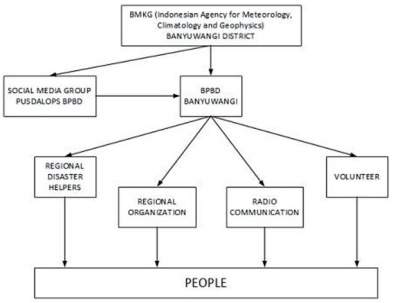


Figure 3: Current BNSP Flow Diagram of Early Warning System in Banyuwangi (Bencana, 2015).

Therefore it is needed a simple information flow to the people with a simple way but accurate information. The simple and fastest sharing information today is internet, by using internet network the information can be received by the people in the fastest way. Beside that an android application can make the people easy to get detail information. The application of this method is an EWS (Early Warning System) application as shown in Figure 4.

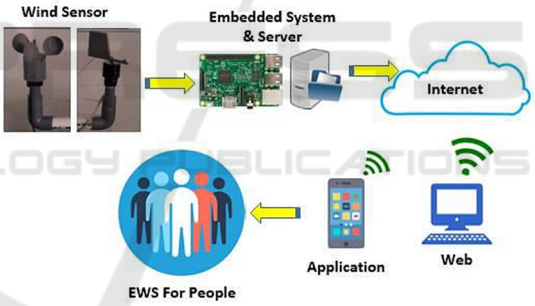


Figure 4: EWS of Windstorm Design System.

3 DEVELOPMENT PROCESS

3.1 Embedded System Preparation

The development of the computer world is currently so fast and one of them is embedded system. Embedded system or mini computer is smart equipment which has microcontroller and the programming system inside. Embedded system also has ability to control and monitor the performance of equipment (Susanti et al., 2018).

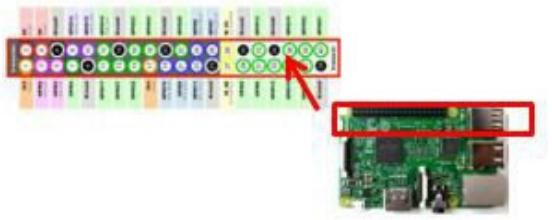
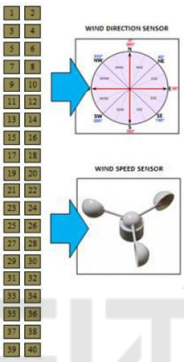


Figure 5: General Purpose Input Output(GPIO) Raspberry pi 3 pin schematic diagram (Vatsal and Bhavin, 2017).

In this research use Raspberry pi 3 for embedded system because Raspberry pi 3 has been equipped with wireless network. The sensor connections to the Raspberry pi 3 as shown in Figure 5 and Figure 6 below diagram.



GPIO Pin	Pin Fuctions	Note
3	*Input*	Hall sensor for wind speed
11	*Input*	Photo dioda for wind direction (North)
12	*Input*	Photo dioda for wind direction (West)
13	*Input*	Photo dioda for wind direction (East)
15	*Input*	Photo dioda for wind direction (South)
11 and 13	*Input*	Photo dioda for wind direction (Northeast)
13 and 15	*Input*	Photo dioda for wind direction (Southeast)
15 and 12	*Input*	Photo dioda for wind direction (Southwest)
11 and 12	*Input*	Photo dioda for wind direction (Nortwest)

Figure 6: Raspberry pi 3 to sensor diagram.

3.2 Sensors Preparations

There were two main sensors in this system, wind speed sensor and wind direction sensor.

3.2.1 Wind Speed Sensor and Wind Directions Sensor

This sensor use bowl propeller to catch wind movement and convert it to the wind speed measurement. The bowl propeller was made by using 3D printer with filament material as below Figure 7 design picture.

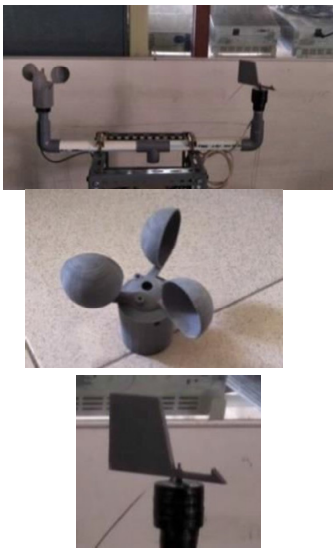


Figure 7: Wind Speed and Direction Sensor.

In this research use Hall Effect to change the rotation of bowl propeller become measurement of wind speed. In the Hall Effect sensor there is a mechanism to detect the magnetic field come near to or keep off from the sensor. Then the changing will be changed to be voltage pulse according to the frequency of come near to or keep off from the sensor. Finally the frequency will show a lot of rotation of a wind speed sensor which will be changed in Km/h. The block diagram flow of detections is shown in Figure 8.

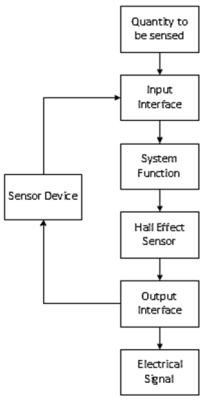


Figure 8: General Sensor Block Diagram Based on The Hall Effect (Krishna and Abraham, 2014).

The Wind Direction sensor used photodiode, which have a characteristic the resistance will changethe value if there are light on the photodiode. The resistance of the photodiode depends on light

intensity received. Figure 9 explain that the sensor used to indicate the direction of the wind by LED as lighting source and photodiode mechanism.

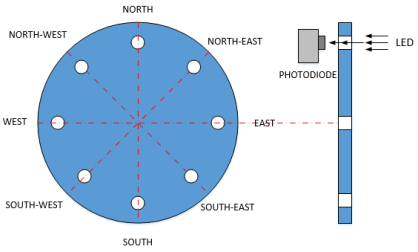


Figure 9: Photodiode, LED and wind direction.

3.3 Web and Application

This research also takes a web and android application to show the data sensor and give notification as early warning of windstorm to the people as shown in Figure 10. In this web there were location of sensor windstorm, wind speed graph, highest wind speed, information-tips and data report. The information of windstorm was not only on web but in the android application also. The purpose this application was to give information to the people about wind speed, direction and windstorm early warning system by using internet connection.

Figure 10: Web Dashboard of EWS and Splash Screen Application EWS.

4 EXPERIMENT

There are some levels of wind speed based on Beaufort standard as mentioned in Tabel 1 below (Stewart, 2008):

Table 1: Beaufort Wind Scale and State of the Sea.

Beaufort Number	Descriptive term	m/s	Appearance of the Sea
0	Calm	0	Sea like a mirror
1	Light Air	1.2	Ripples with appearance of scales; no foam crests.
2	Light Breeze	2.8	Small wavelets; crests of glassy appearance, not breaking
3	Gentle breeze	4.9	Large wavelets; crests begin to break; scattered whitecaps.
4	Moderate breeze	7.7	Small waves, becoming longer; numerous whitecaps
5	Fresh breeze	10.5	Moderate waves, taking longer to form; many whitecaps; some spray
6	Strong breeze	13.1	Large waves forming; whitecaps everywhere; more spray
7	Near gale	15.8	Sea heaps up; white foam from breaking waves begins to be blown into streaks.
8	Gale	1.8	Moderately high waves of greater length; edges of crests begin to break into spindrift; foam is blown in well-marked streaks.
9	Strong gale	22.1	High waves; sea begins to roll; dense streaks of foam; spray may reduce visibility
10	Storm	25.9	Very high waves with overhanging crests; sea takes white appearance as foam is blown in very dense streaks; rolling is heavy and visibility reduced
11	Violent storm	30.2	Exceptionally high waves; sea covered with white foam patches; visibility still more reduced
12	Hurricane	35.2	Air is filled with foam; sea completely white with driving spray; visibility greatly reduced

Windstorm is a strong wind which has a potential to destroy any kind around it. In BNPB Banyuwangi district, windstorm has speed 50 Km/h, it's mean this categorize in the Beaufort number 7. That why in this research danger notification of windstorm was sent to the people when wind speed above 50 Km/h.

4.1 Experiment Method

The experiment was done in the Lab Hardware, State Polytechnic of Banyuwangi. And it was done with below scenario.

- The experiment was done to check the functionality of the EWS on the web based and android application based.
- Windstorm detection experiments were done on there step trial with air compressor blower as windstorm resource.
- The windstorm detections based on critical sensor location and in this trial used one critical location was Rogojampi area.
- The there steps of trial based on sensor with wind compressor spray distance to measure wind speed. These distances were 300 cm, 200 cm and 70 cm.

5 RESULT AND ANALYSIS

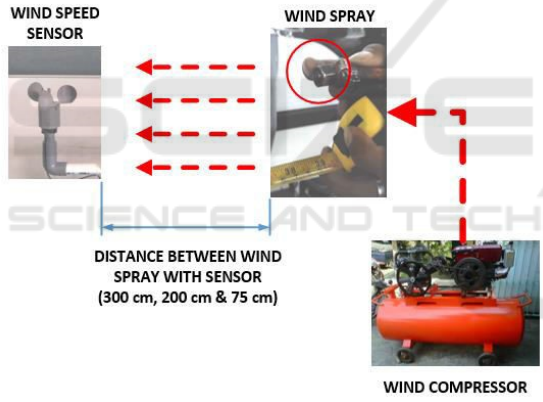


Figure 11: Wind Flow Trial.

In this research functional test by using wind flow trial as descraibed in Figure 11 with two main categories, first category was low speed wind (with distance 200 cm & 300 cm) and second category was high speed wind (with distance 75 cm). The wind spray compressor blow the wind directly to the wind speed sensor surface and found as below result.

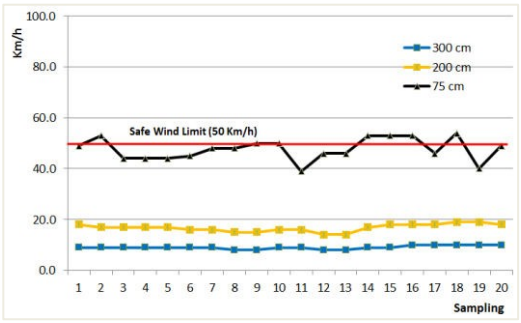


Figure 12: Wind Speed Result.

Figure 13: Graphic speed, Critical Location of Windstorm and Direction.

Refer to Figure 12 and Figure 13, that wind sensor could detect wind speed in low speed category and high speed category. The red line in the graph on the 50 Km/h was safe wind limit of speed and trial with distance 75 cm made result until over safe wind limit of speed. Its mean this sensor could detect wind speed until Windstorm category. On the high speed (windstorm category) was also detect and give warning notification as early warning system to the people as shown in Figure 14 below:

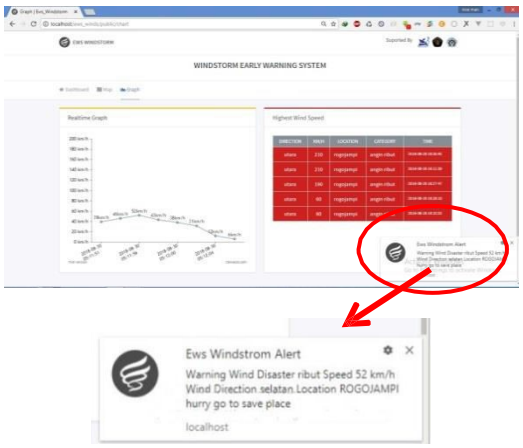


Figure 14: Web Based, EWS Warning System.

Figure 15 described that in this research also made an android application with EWS system to inform danger notification to the people.

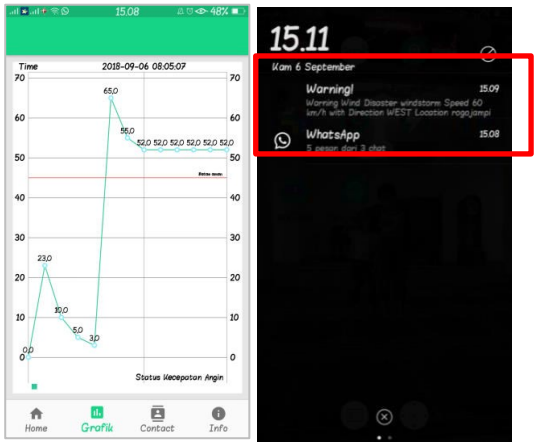


Figure 15: Real Time Android Based Application, Graphic and EWS Notification.

By using an android application made the windstorm information received to the people quickly compare to conventional BNSP Banyuwangi District Early Warning System flow notification.

5 CONCLUSION

One of an important thing in the disaster management is early warning system. By using EWS the information of disaster danger can inform quickly and accurately. This research propose a system EWS for Banyuwangi district based on android application, web based and IoT technology. A real time information become advantages for people to prepare and protect their property or life from windstorm disaster. Through android application also made information could easily access by people and warning system notification very useful for people. These results prove that this EWS system can detect windstorm, inform warning information quickly than conventional way and easily to use for people. The main issue show that the critical location also take an important aspect for early detection system This research also gives a step to make next research with multiple sensors for deeply information of disaster.

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