Development of forest fire early warning system based on the wireless sensor network in Lawu Mountain.

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Abstract. Early detection of forest fires is important to reducing the problem of forest land abatement by 2% each year. The use of sensors for monitoring is still very low so that it is very necessary to reduce the existence of forest fires. The method is done by measuring the temperature and gas content (CO, CO₂) which is then divided into four levels, which are Normal, Level 1, Level 2 and Level 3, based on sensor readings value. Using temperature sensor and gas sensors which are both integrated with microcontroller and GSM module to send a mass SMS alert than can be viewed by users with the level of conditions read by the device. This tool will be placed around the hiking trail of Lawu Mountain.

1. Introduction
At least 1.1 million hectares or 2% of Indonesian forest is decreasing every year [1]. One of the most causes from this abatement is fire forest. These fire forests have an important impact on ecological destruction, distemper and absolutely disturbing transportation [2]. There is 5144 hotspot from LAPAN satellite which is included in conditions prone to fire from January to October 2017. This indicates that there are still many points that have the potential for forest fires in Indonesia [3]. Forest fires can increase the level of gas present in the area. In the event of a forest fire, the released gases are carbon dioxide, carbon monoxide, hydrocarbons. CO₂ is the largest emission that is released into the atmosphere as a result of combustion. Along with water vapor CO₂, CO is generally produced by incomplete combustion of moist (wet) fuel and includes air pollutants [4]. Recently, especially in Indonesia, the use of sensors for monitoring is still lacking and still rely on manual monitoring by the human as a condition forest monitor [5]. Lawu mountain forest is one of the forest in Indonesia that is prone to and potentially occur forest fires. The last recorded was a forest fire in October 2015 and the most recent in June 2018. The wireless sensor network consists of individual nodes that can interact with their environment by sensing, controlling and communication to their physical parameters [6]. Previous research has been conducted by [7] on fire detection based on the wireless sensor network, but in that research did not use gas sensors and also there is no level of condition based on detection by sensors. In addition, previous studies are not easily conveyed to the users.

In this paper is added with a gas sensor and directly addressed to the user's phone as an alert via mass SMS GSM with three level of condition around the sensors. This will make it easier for users to control forest fires and monitoring system Wireless Sensor Networks with SMS GSM alerts is the best solution to reduce and anticipate the potential for forest fires.
2. Experimental Methods

This tool is developed for environmental monitoring which prone to fire based on microcontroller and GSM. In this section consist of how to collect the data and processing until it can be used by users.

2.1. EWS monitoring design

This system consists of Solar Cell 50 wp, Solar Charge Controller, Battery 12v, microcontroller Arduino UNO, SIM900A GSM module, MQ-7 gas sensor, DS18B20 temperature sensor, and a mobile phone. Figure 1 shows block diagram of the EWS monitoring system.

Arduino Uno as the main unit is a microcontroller board with ATmega328 microprocessor built-in. This board has 14 digital input or output pins (where 6 pins can be used as PWM output), 6 analog inputs, 16 MHz crystal oscillator, USB connection, power jack reset button. These pins are all that is needed to support the microcontroller. Meanwhile, to connect to a computer can use a USB cable or voltage source that can be obtained from the AC-DC adapter or the battery [8]. The main unit processing all data obtained by sensors. Sensor MQ-7 is a carbon monoxide gas (CO) sensor that serves to determine the concentration of carbon monoxide (CO) gas. This sensor requires a simple circuit and requires 5V sources, load resistance, and sensor output connected to an analog-digital converter (ADC) so that the output can be displayed in digital signal [9].

GSM Shield is an integrated board designed with Arduino that has a function to be able to send SMS, make voice calls or connect the internet using a wireless network that connects with other networks with the sync node, which in turn the user can access remotely and manage it. [10,11]. GSM Shield is used as a tool to communicate via SMS between Arduino and user’s phone. SMS (Short Message Service) is the ability to send and receive text messages from and to mobile [12].

2.2. Working System

The working system of this tool is started by reading and measuring the gas content and temperature. Then the reading result will be processed by the main unit to determine whether it can be in Normal, Standby, Alert or Caution Levels. If the results show the normal level, then the system will repeat until found other than normal conditions. Other than normal conditions will be sent as an alert messages GSM in time intervals. Figure 2 shows the working flow from the device early warning system forest fires in Lawu mountain.
2. Level of Condition

Level of the condition is determined based on the readings of the sensor. Where each level has different sensor readings values. However, both conditions of the reading value of the gas sensor and the temperature sensor must be met. If it refers only to one sensor reading, there may be differences in reading conditions by the system under actual conditions.

The following is the determination of the value of each sensor for the level condition of early warning system forest fires in Lawu mountain.

| Level   | Temperature Value (°C) | Gas Value (PPM) |
|---------|------------------------|-----------------|
| NORMAL  | < 30                   | < 200           |
| LEVEL 1 | 30 < T < 40            | 200 < G < 800   |
| LEVEL 2 | 40 < T < 50            | 800 < G < 1800  |
| LEVEL 3 | > 50                   | > 1800          |

3. Result and Discussion

This device is designed and developed as an early detection of forest fires, especially in Lawu mountain forests that are integrated with GSM signals making it easier for users to control the condition of the forest. Composed of four parts of resources, main unit, sensors, and data unit. Here uses two sensors, temperature and gas sensors that can be used to detect environmental conditions in the form of rising temperatures and levels of gas which is indicated as a sign of a forest fire. Then from the sensor readings, will be forwarded by the main unit, which then the output can be viewed on the user's mobile.
phone screen via massage GSM. The warning system itself is divided into four conditions, there are Normal, Level 1, Level 2 and Level 3 with each reference mark that has been determined.

Sending data readings are processed with SIM900A GSM module that integrated with Arduino Uno microcontroller. Based on the results of the test, message alert cannot directly send to the user's mobile phone. But there is an average delay of about 5 seconds. It also depends on the signal obtained from the device, because the unstable GSM signal also affects the performance of the response of the device itself. Figure 3 shows one of the results during the test and the devices.

Figure 3. (a) User’s phone interface during test and (b) the device early warning system forest fires in Lawu mountain

4. Conclusions

We developed this system to become one of the preventive efforts in a problem of forest fires in Lawu mountain. This tool is able to distinguish the level of forest fire disaster with parameters of gas content and temperature rise. Using MQ-7 and DS18B20 as a gas sensor and temperature sensor integrated with Arduino UNO microcontroller. The result of the reading condition is then sent to the user's mobile phone via GSM massage using SIM900A GSM module.

Level of condition readings still has a gap of about 5 seconds until it sent to the user's phone. But each system has efficiency at work and that results are reasonable including for early detection of forest fires with large distances and areas. On the other hand, there are still many evaluations that we have found such as the area of reading tools that are still less extensive if only using one tool only, so for more accurate results, requires the installation of tools scattered in the forest. It is also related to the development of sensors that can be added with other parameters to improve the accuracy of analyzing the condition of the forest with the actual conditions.

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