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Early Warning System for Potential Fires in the Dry Season Based on the Internet of Things

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Abstrak

Hampir setiap tahun terjadi kebakaran hutan dan lahan di Indonesia yang dampaknya dirasakan oleh masyarakat sekitar dan negara tetangga. Seperti kebakaran baru-baru ini di Kotawaringin Timur dan Katingan, Kalimantan Tengah. Lahan yang terbakar diduga merupakan konsesi milik perusahaan Malaysia. Menurut Kementerian Lingkungan Hidup dan Kehutanan, luas kebakaran hutan dan lahan dihitung berdasarkan analisis citra satelit Landsat 8 OLI/TIRS, yang dibandingkan (overlay) dengan data sebaran titik api. Dalam penelitian ini, Internet of Things (IoT) dapat bermanfaat dalam mencegah kebakaran hutan yang biasa terjadi di lereng Merbabu saat musim kemarau. Teknologi sensor IoT dapat mendeteksi parameter kelembaban udara, suhu, dan kecepatan angin untuk kebakaran di musim kemarau. Penelitian ini bertujuan untuk memperingatkan potensi kebakaran hutan dan lahan di Gunung Merbabu dengan memberikan notifikasi dari sensor IoT. Dari pengujian sensor yang telah dilakukan, dapat diketahui bahwa sensor dapat memberikan informasi secara akurat dan real-time. Pengujian dilakukan di tiga tempat yaitu di kaki Gunung Merbabu, Puncak FTI UKSW, dan persawahan. Hasil yang berbeda di tiga tempat dengan indeks vegetasi yang berbeda menunjukkan bahwa desain sistem peringatan potensi kebakaran berbasis Internet of Things pada musim kemarau (Juli – September) dapat digunakan di daerah dengan indeks vegetasi rendah di lereng Gunung. Merbabu yang sebagian besar merupakan padang rumput kering dan mudah terbakar..

***Kata kunci*:** *Internet of Things, Indeks Vegetasi, Potensi Kebakaran, Musim kemarau, Lereng Merbabu, Sensor*

Abstract

Almost every year, forest and land fires occur in Indonesia, the impact of which is felt by the surrounding community and neighboring countries. Such as the recent fires in East Kotawaringin and Katingan, Central Kalimantan. The land affected by the fire is believed to be a concession belonging to a Malaysian company. According to the Ministry of Environment and Forestry, the area of forest and land fires is calculated based on an analysis of Landsat 8 OLI/TIRS satellite imagery, which is compared (overlay) with data on the distribution of hotspots. In this research, the Internet of Things (IoT) can be useful in preventing forest fires that usually occur on the slopes of Merbabu during the dry season. IoT sensor technology can detect air humidity, temperature, and wind speed parameters for fires in the dry season. This study aims to warn of potential forest and land fires in Mount Merbabu by providing notifications from IoT sensors. From the sensor testing that has been done, it can be seen that the sensor can provide information accurately and in real-time. The tests were carried out in three places: at the foot of Mount Merbabu, the SWCU FTI Peak, and the rice fields. The different results in three places with different vegetation indices indicate that the design of a fire potential warning system based on the Internet of Things in the dry season (July – September) can be used in areas with a low vegetation index on the slopes of Mount Merbabu, the majority of which are dry and easy grasslands burnt.

Keywords: Internet of Things, Vegetation Index, Fire Potential, Dry season, Merbabu Slope, Sensor

1. INTRODUCTION

Almost every year, there are forest and land fires in Indonesia, whose impact is felt by the surrounding community and neighboring countries (Cabucci & Maulina, 2021; Wibowo et al., 2021). Population development continues to grow without employment opportunities, so much forest land is turned into plantation land (Firdaus et al., 2022; Jamalludin et al., 2021). Land clearing for plantations in Indonesia is mostly done conventionally by burning forests to become plantation land (Jamalludin et al., 2021; Kusumastuti et al., 2018). One of the islands aggressively converting forest land into plantation land is the island of Sumatra (Setiawan & Yanto, 2018). Such as the recent fires in

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East Kotawaringin and Katingan, Central Kalimantan. The land affected by the fire is believed to be a concession belonging to a Malaysian company. According to the Ministry of Environment and Forestry, the area of forest and land fires is calculated based on the analysis of Landsat 8 OLI/TIRS satellite imagery, which is compared (overlayed) with hotspot distribution data. This data is also combined with the results of the hot spot ground check and blackout reports conducted by Manggala Agni. One of them was a fire at Mount Merbabu. The area where the vegetation was burned was in the form of shrubs and undergrowth. However, several perennials were also burned, including acacia decoren and puspa. Several things hampered efforts to extinguish the fire. Among other things, very hot weather and burning vegetation in the form of shrubs and undergrowth. Then the strong winds made the flames grow bigger and spread easily.

Technological developments are growing rapidly from time to time (Antara et al., 2022; Suša, 2014). From smart cars that can run independently to various destinations without a human driver to smart home devices such as Alexa that automatically make a sound that reminds you to do activities according to schedule (Khan & Naseer, 2020; Rohida, 2018). All these new technologies are part of the Internet of Things. Internet of Things (IoT) is a concept in which an object can transfer data over a network without requiring human-to-human or human-to-computer interaction (Jamil et al., 2019; Muktiawan & Nurfiana, 2018). IoT is a structure in which objects and people are provided with an exclusive identity and the ability to move data across a network without requiring two-way human-to-human, i.e., source-to-destination or human-to-computer interaction (Burange & Misalkar, 2015). IoT does not have a fixed definition. There is always a discussion about whether it comes from our daily life to objects that can be used as devices to facilitate our activities.

IoT can be useful for preventing forest fires that usually occur in the Mount Merbabu area during the dry season. IoT technology can detect air humidity, temperature, and wind speed which are parameters for fires in the dry season. This study aims to warn of potential forest and land fires in Mount Merbabu by providing notifications from IoT sensors. There are several studies related to IoT, namely research on the design of smoke and fire detection systems based on sensors, microcontrollers, and IoT. This study aims to design and build a smoke and fire detection system based on sensors, microcontrollers, and IoT, which can be used to detect potential fire hazards in certain homes or buildings. The research method in designing this system refers to the Prototyping model. The components used are smoke sensors, fire sensors, microcontrollers, LEDs, and buzzer alarms, which are integrated with the Blynk IoT platform. The study results are in the form of an IoT-based smoke and fire detection system, which provides early warnings about potential fires through alarms and text message notifications on smartphones. This system can help detect and avoid potential fire hazards (Waworundeng, 2020).

Another research is developing a forest fire early warning system using the nodemcu module and BOT Telegram with the Internet of Things (IoT) concept. Based on the test results, the forest fire early warning system using the Nodemcu and BOT Telegram modules with the Internet of Things (IoT) concept is very helpful in providing fast information to find out fires that occur in the forest, using the Internet of Things method, officers will be able to determine the condition in real time because this technology can monitor hardware using internet communication facilities in the form of Telegram so that distance and location are not affected as long as the sensors used to detect changes that occur (Jamil et al., 2019). In line with this research, similar research shows that the Internet of Things (IoT) can be used in this study. This study aims to (1) determine the ability of geospatial technology to identify biophysical parameters of potential forest fires and (2) determine spatial distribution patterns of potential forest fires based on interrelational parameters. Spatial biophysical interpretation of geospatial technology, and (3) compiling a spatial model to determine the distribution of

potential forest fires on the southern slopes of Mount Merbabu. The research population is the entire terrain on the southern slope of Mount Merbabu (Rahmawati & Sumunar, 2018).

Based on several previous research results on the application of IoT, this study will use four sensors to detect potential fires. These sensors are adjusted to the parameters that cause fires in the Mount Merbabu area with a low vegetation index. Temperature, humidity, wind speed, and fire are the main factors causing fires in Mount Merbabu during the dry season, so in this study, a tool will be made to detect the presence of hotspots using IoT marketed in areas with low vegetation index on Mount Merbabu. With this IoT device, users will get real-time notifications about the possible presence of hotspots so that forest and land fires can be prevented on Mount Merbabu.

2. METHODS

The design of the IoT application for detecting potential fires in the dry season is presented in Figure 1. Sensors will be placed on dry fire spots with a very low vegetation index. The sensor requires an internet network to send notifications to users.

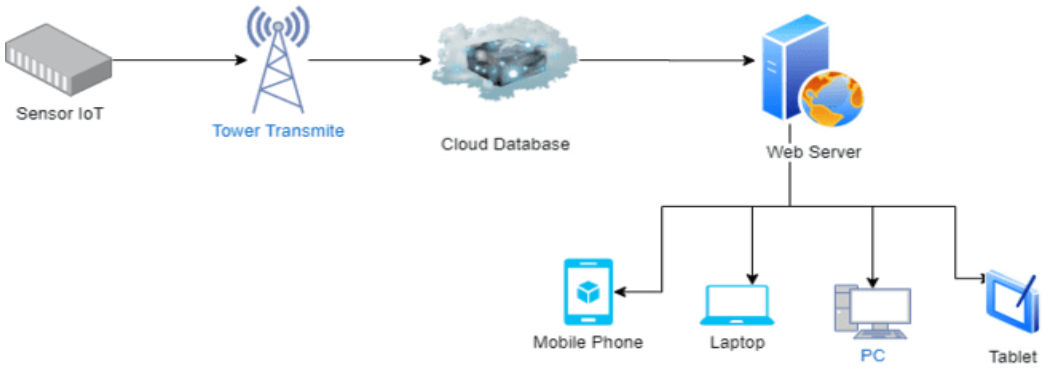

Figure 1. *Workflow* IoT Fire Potential Detector

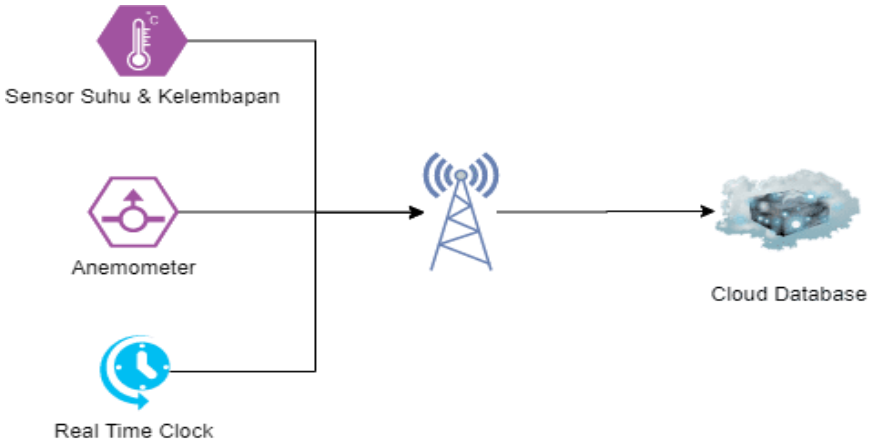

Figure 2. Sensor Data Delivery Process

Figure 2 shows the data transmission flow from the sensor to the cloud database. In the picture, there are three measuring instruments, namely (1) temperature and humidity sensors, (2) wind speed gauge, and (3) Real Time Clock. The measuring instrument used is an IoT sensor that is adjusted to the factors that cause fires that occur in the dry season. Any data captured by the IoT sensor will be sent using the internet so that the data can be accommodated into a cloud database to be forwarded to IoT users.

Table 1. Fire Potential Parameters

Sensor	Parameter
Temperature	> 36ºC (Very High)
	29 – 36ºC (High)
	21 – 29 C (Medium)
	< 21ºC (Low)
Humidity	> 96 (Very High)
	70-96 (Height)
	22-70 (Medium)
	< 22 (Low)
Wind speed	Catalyst
Fire	Yes / No

Table 1 explains that each sensor has parameters used as benchmarks for IoT sensors to send notifications to users. Temperature and humidity, which are the main components of a fire, have their respective sizes from low to very high categories. The wind is a catalyst that can accelerate the occurrence of friction, so that dry areas and hot temperatures with large wind speeds can potentially cause fires in the area.

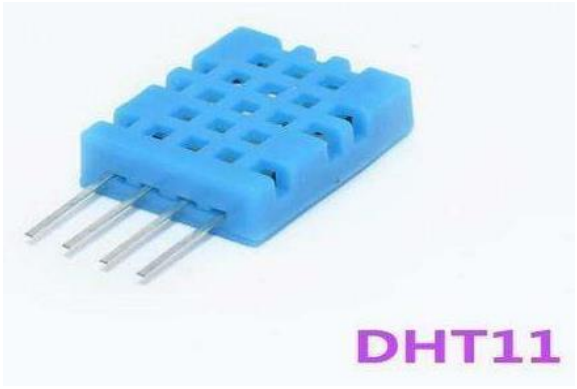

Figure 3. DHT11

The air humidity in the Merbabu mountain area in the dry season is very dry, so a temperature and humidity sensor (DHT11) is used to determine the temperature and humidity levels in the area. The DHT11 sensor (Figure 3) is a sensor with a digital signal calibration capable of providing temperature and humidity information. DHT11 has a very accurate calibration feature. This calibration coefficient is stored in the OTP program memory so that when the internal sensor detects something temperature or humidity, this module reads the sensor coefficient. Small size, with signal transmission up to 20 meters (Adiptya & Wibawanto, 2013).

Figure 4. Anemometer

The wind speed gauge consists of a sensor in the form of a bowl vane connected to a perforated disk and an optocoupler sensor, as shown in Figure 4. The bowl vane is connected to a perforated disk which is used to calculate the rotational speed of the bowl vane. The center point of the disk and the center point of the bowl vane is connected by an axis so that the disk rotates according to the speed of the propeller on the bowl (Derek et al., 2016). The wind, which is a catalyst, plays an important role in the process of fires at a certain temperature and humidity level so that hot temperatures and dry humidity with large wind speeds will produce friction that can trigger the emergence of small hotspots in the Merbabu mountain area during the dry season. Real-Time Clock / RTC is a real-time module that runs the time and calendar functions based on the DS1307 by using a backup supply as a battery. RTC / Real-time clock is an electronic clock in the form of a chip that can accurately calculate the time from seconds to years and store the time data in real-time. RTC also often integrates into other devices or devices. For example, the broadband communications IC is used in car radios.

3. RESULTS AND DISCUSSION

Result

Sensor Design

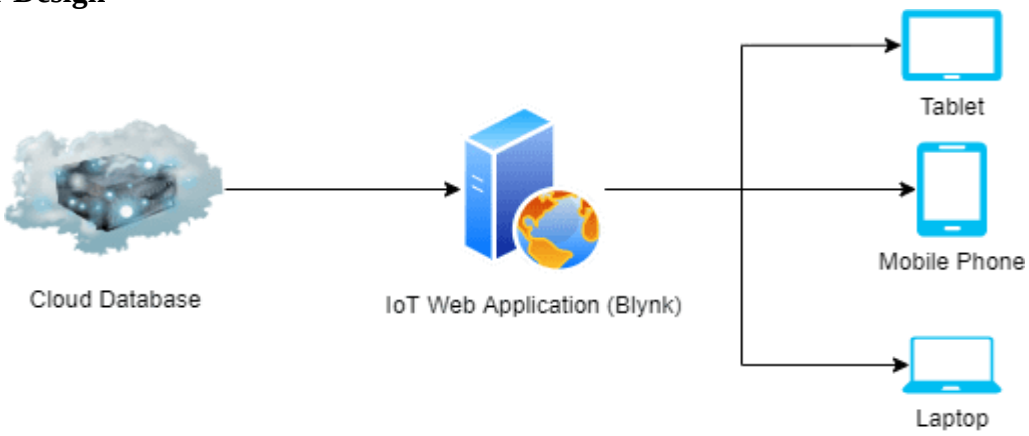

Figure 5. Data Delivery Flow

Figure 5 is the process flow for sending data from the cloud database to the user through the IoT web application. Real-time data sent by sensors and stored in the cloud database will be pulled by the web application and processed to calculate each parameter that has been determined. Each parameter will generate a notification for the user so that it can be used to prevent fires on Mount Merbabu during the dry season.

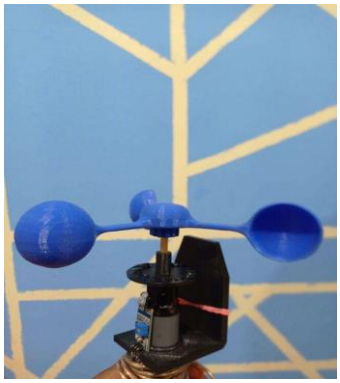

Figure 6. Design of Temperature, Humidity, and Wind Speed Detector Sensors

The design of the Temperature, Humidity, and Wind Speed sensors that have been assembled into one IoT device, which is then implemented in places with different vegetation indices, is shown in Figure 6. The places where the IoT sensors are implemented are (1) Mount Merbabu, Cuntel Village, Magelang (low temperature, low humidity); (2) The peak of the SWCU FTI, Gunung Payung, Salatiga (high temperature, low humidity); (3) Rice fields (high temperature, low humidity). The selection of the place to be used as the location of the sensor for detecting potential fires is based on a low to high vegetation index with varying levels of temperature, humidity, and catalysts.

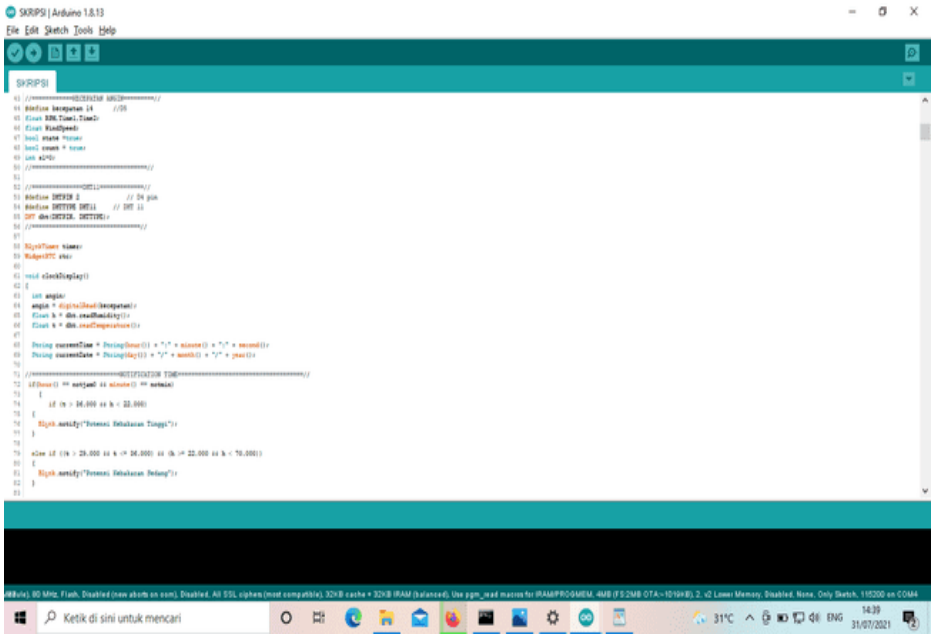

Figure 7. Arduino Uno Application

The Arduino Uno application, used to run the IoT sensor tool to collect any real-time data sent by the sensor, is presented in Figure 9. The data collected in the cloud database (firebase) is then processed with the code, as shown in Figure 8.

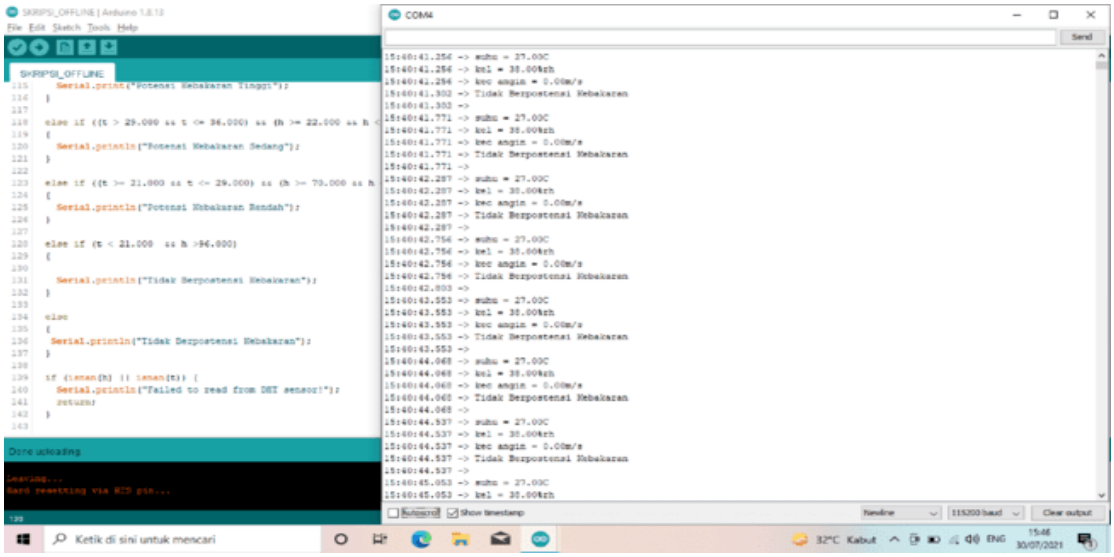

Figure 8. Arduino Application Coding

Figure 8 is coding using C language, starting with entering the sensor library and then token authentication on the Arduino Uno application, followed by functions such as setting the SSID and Wifi password, initializing the DHT11 & Anemometer device PIN, calling functions from each DHT11 & Anemometer device, initializing Virtual Real Time Clock (RTC), Arduino time sending function and sending data to Blynk application in real-time, serial and server setting function for sending data, data transmission loop (VoidLoop). The real-time data sent by the IoT sensor is called by the coding process and then iterated using VoidLoop. It is done so that the application can repeatedly accommodate every state of temperature, humidity, and wind speed around the IoT sensor with conditions as shown in Table 2.

Table 2. Interpretation of Temperature, Humidity, and Wind Speed

Condition	Interpretation
Temperature < 21ºc & Humidity > 96%rh	No Fire Potential
Temperature >= 21ºc - <=29 c & Humidity >= 70%rh - <=96%rh	Low Fire Potential
Temperature > 29ºc - <=36 c & Humidity >= 22%rh - < 70%rh	Medium Fire Potential
Temperature > 36ºc & Humidity > 22%rh	High Fire Potential

The Blynk application is an application that is run using a mobile phone. The application displays data visually from a cloud database that is run using the Arduino Uno application. The picture shows the real-time data sent by the temperature, humidity, and wind speed sensors. The blynk application shows that at 16:44 local time, the temperature reached 22ºC with air humidity reaching 2% rh with no wind gusts. From these data, it can be concluded that the temperature and humidity at that time were in a condition that did not have the potential for a fire to occur because a low temperature still balanced the low humidity. There was also no wind gust which was a catalyst for sparks.

Sensor Test

Mount Merbabu

The sensor was placed in the village of Cuntel Kopeng, Magelang Regency, the base camp for climbing Mount Merbabu. The sensor is placed right on the initial climbing route of Mount Merbabu via cuntel, which has a fairly low vegetation index. Of the four results displayed by the Blynk application, the sensor gives a "no fire potential" notification. It is because the temperature is between 22ºc - 26ºc (medium) with humidity between 2%rh - 26%rh (low - medium) accompanied by gusts of wind that are not enough to trigger sparks. With these conditions, there is no potential for fires around the sensor placement point.

Top of FTI

The sensors were placed at the top of Mount Umbrella, Salatiga city, which is close to the SWCU Information Technology Faculty (FTI). The sensor is placed in a dry grass area with a very low vegetation index. The results of the sensor test at the foot of the SWCU FTI Peak displayed by the Blynk application showed the sensor gave "no fire potential" and "High Fire Potential" notifications. It is because the temperature is between 33ºc - 40ºc (high - very high) with humidity between 6%rh - 12%rh (low) accompanied by gusts of wind that are not enough to trigger sparks. With these conditions, there is the potential for fires around the sensor placement point due to the high enough temperature and very low humidity. Still, without a catalyst as a trigger for sparks, there was no fire then.

Rice fields

Sensors are placed around Salatiga-Glawen street, Pabelan, Kab. Semarang. The sensor is placed in a green rice field area with a high vegetation index. The test results displayed by the Blynk application show that the sensor gives a "no fire potential" notification. It is because the temperature is between 34ºc - 35ºc (high) with humidity between 12% and rh (low) accompanied by wind gusts that are not enough to trigger sparks. With these conditions, there is no potential for fires around the sensor placement point. From the sensor testing that has been done, it can be seen that the sensor can provide information accurately and in real-time. Tests conducted in three different places showed that the design of an Internet of Things-based fire warning system in the dry season (July – September) could be used in areas with a low vegetation index on Mount Merbabu, the majority of which are dry and flammable grasslands.

Discussion

The Internet of Things is often referred to by its abbreviation, IoT, without requiring human-to-human interaction or human-to-computer devices (Muktiawan & Nurfiana, 2018; Rohida, 2018). IoT has developed rapidly from the convergence of wireless technology, micro-electromechanical systems (MEMS), and the internet. IoT is also often identified with RFID as a communication method. IoT can also include other sensor technologies, such as wireless technology or QR codes we often find around us (Burange & Misalkar, 2015; Lombardi et al., 2021). IoT can be used to monitor and control a certain place. This technology makes it easier for people to share things by being connected via both local and internet networks. Some things that can be done with IoT include transferring data over a network without requiring humans for human or human-to-computer interaction, remote control capabilities, and so on. The main principle of IoT is to make it easier to monitor and control things so that the IoT concept can be applied to daily activities (Vinola et al., 2020). In this study, IoT is used as an early warning system for potential fires in the dry season, especially on the slopes of Mount Merbabu.

The vegetation index is an algorithm applied to digital images highlighting vegetation aspects such as density. The transformed image is used to determine the level of vegetation density. The highest vegetation index value in the image is represented by green, and the lower is red, which represents the lowest pixel value. From the parameters of vegetation types in May, it was found that pine has the highest vegetation index value of 0.59634, and the lowest value is found on unvegetated land with a vegetation index value of 0.01563. While in the dry month of July, the highest vegetation index value is 0.58183, and the lowest value is found on unvegetated land with a vegetation index value of 0.03130 (Rahmawati & Sumunar, 2018). Almost every year, forest and land fires occur in Indonesia, the impact of which is felt by the surrounding community and neighboring countries. Several things hampered efforts to extinguish the fire. Among other things, very hot weather and burning vegetation in the form of shrubs and undergrowth. Then the strong winds made the flames grow bigger and spread easily. In this research, IoT can be useful for preventing forest fires that usually occur in the Mount Merbabu area during the dry season. IoT technology can detect air humidity, temperature, and wind speed which are parameters for fires in the dry season. This study aims to warn of potential forest and land fires in Mount Merbabu by providing notifications from IoT sensors.

By utilizing a combination of a temperature and humidity sensor (DHT11) and also a wind speed meter (anemometer), the IoT system can provide accurate and real-time information where data from the sensor is stored in a cloud database and then sent using the Arduino Uno application and displayed to users using the application. The notification displayed on the blynk application shows that the parameters configured on the Arduino Uno

application are running well. IoT can detect potential fires in the dry season, especially on the slopes of Mount Merbabu. This study has several limitations, such as sending data that still requires an internet signal (wifi). In this case, it is hoped that SIM cards in IoT systems can be developed so that sensors only need to use cellular internet signals to transfer data to the cloud database.

4. CONCLUSION

This study aims to warn of potential forest and land fires in Mount Merbabu by providing notifications from IoT sensors. By utilizing a combination of a temperature and humidity sensor (DHT11) and also a wind speed meter (anemometer), the IoT system can provide accurate and real-time information where data from the sensor is stored in a cloud database and then sent using the Arduino Uno application and displayed to users using the bylink application. The notification displayed on the blynk application shows that the parameters configured on the Arduino Uno application are running well. IoT can detect potential fires in the dry season, especially on the slopes of Mount Merbabu.

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