Forest Fire Detection and Warning System for Disaster Prevention

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***Abstract*— Natural disasters and human-made disasters around the world occur everywhere. Among them, the disasters which can be caused by forest fires cause a lot of damage to humans. Forest fires can be caused by natural causes or by human activities. Forest fires can be caused by huge damage to human habitats and forest ecosystems. Forest fires affect the global climate changes and greenhouse effects. Therefore, real-time fire detection and warning systems are needed to prevent wildfire natural disasters. This proposes system can be used to detect forest fires at the initial stage using a wireless sensor network. In this paper, using Arduino (ATmega 2560), it is a system that can monitor forest fire from sensors. This system is composed of sensors, ESP 8266, Gateway and Arduino. This proposed system implements the effective detection and warning system for based on wireless sensor networks (WSN). The aim of this proposed system is to achieve forest fire disaster prevention and warning benefits using IoT technology.**

Keywords—Detection System, Warning System, Internet of Things, Wireless Sensor Network

I. INTRODUCTION

Wildfire is one of the worst forest disasters. Forests play the important role in such sectors as ecological, biological and environmental development. Monitoring, detection, and protection should be done from time to time to prevent forest fires. Systematic assessments of the potential impacts of forest fires are forest fire prevention and monitoring. Natural processes and global climate change can cause forest fires, but human activities are causing more wildfires.

Wildfires can cause regeneration of some species. Otherwise, it mostly causes more negative consequences for the ecosystem and humans. Forest fire early warning systems, real-time detection and reporting systems can enable rapid response and reduce damage. The forest areas in Myanmar are about 42 percent of the country's area. The expansion of agricultural land by rural people has led to massive forest fires. In 2022, among the five countries in Mekong sub-region, it is observed that Myanmar had the largest number of forest fire areas with 26,000. Forest fires in Myanmar are most common in such places as Kayah State, Chin State, Karen State, Shan State, Magway Region, Mandalay Region and Nay Pyi Taw Council Area.

This system is composed of sensors, ESP8266 and Arduino. This proposed system implements the effective forest fire detection and warning system based on wireless sensor networks (WSN). Smoke sensor (MG 811) will measure the level of carbon dioxide gas (CO2). The flame sensor (LM393, 60 Hz) is used to sense to the occurrence of fire or flame. The temperature sensor (DHT 11) will measure the temperature of the forest area. After that, the weather sensor (WS800 UMB) will measure and analyze of weather condition.

All these sensors collect the necessary data for forest fire system such as smoke, temperature, weather condition and occurrence of fire. All sensors are connected to the Arduino. The sensing data from Arduino will be sent to the cloud (server) which is the control center through ESP8266. When sending to the control center, the router will be used as a gateway. Depending on the data arriving on the cloud, the fire department will be notified in advance if necessary.

II. RELATED WORK

Some related studies about forest fire detection and warning system are discussed in this section.

M. Trinath Basu, Ragipati Karthik, J. Mahitha, V. Lokesh Reddy, "IoT Based Forest Fire Detection System [1]," studying the fire signal based on Node MCU and using the technology of IoT is one of the main reasons for this problem. This paper mentioned that the fire detector utilizes Node MCU connected with temperature sensor, smoke sensor and signal device. A temperature sensor detects the warm temperature of the environment and a smoke sensor is used to detect smoke resulting from a fire. In order to automatically know the cause of a fire, a buzzer is connected to the Arduino as a warning. This warning can be used as a fire warning, even the smallest flame such as a candle or a small amount of smoke from an oil lamp. Similarly, if an environment is getting warmer and the temperature becomes high, it can catch fire, so the fire alarm can be notified in advance. No sooner does normal room temperature or a certain smoke level reach its limitation than the warning will stop. In addition, it is connected and used with the Node MCU to display information on the LCD. This fire inspection can be carried out not only in the factory but also in the family home. It can detect fire or forced fire in any situation, and immediately notify the client of the fire condition through the Ethernet module.

Nithin Kamath, Darshan N Shetty, Loushik N S, Shreyas Rao, Mr. Ramesh Nayak, " IoT Smoke Detection System Using Arduino[2]", prepared an alarm system which is based on indoor smoke, based on Arduino through GSM module. The major task of this system is to prevent smoke levels in the home from being harmful to health and to ensure the health of the occupants of the home. Atmega328 chip is

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utilized in the Arduino board of this system. The main controller is an ATmega328, and a sensor which detects the temperature of the fire is connected to the ATmega328 in order that it gives an alarm for the fire. The LM35 temperature sensor can detect the temperature of the oven in the house and send an emergency warning message to the consumer via SMS in real time through the GSM module.

Deepthi S, Shushma G Krishma, Sahan K B, Vandana H R, Latha M, "IoT Enabled Forest Fire Detection and Management [3]," forest fire detection and management technology is applied. Wildfires have a huge negative impact on the environment and wildlife. On the purpose of preventing them, it is necessary to have an early warning system to control forest fires. Especially if the tracking of the forest fire area is delayed, the use of human power and good transportation will delay the firefighting operations. We found the answer to it by implementing IoT technology to locate the forest fire area. The DHT11 and flame sensor can detect the real-time fluctuations in the temperature and humidity of the forest, and by using the Node MCU microcontroller, which is a Wi-fi module, these values are sent to the database as the cloud. If these values exceed the specified value, an immediate notification will be sent to the relevant forest department through the cloud. If it is done in advance, it will be possible to avoid great losses and the spread of wildfires.

Deena Muthappa, Namratha C, Nayan Joshi, Niharika G V, "Early Detection of Forest Fire Using WSNs [4]," to use a wireless sensor network integrated with firefighting control centers, geographical information systems, and fire simulators in high-risk areas of forests. Currently working on detection systems based on these WSNs, this system has some disadvantages such as latency, high energy consumption and centralized management system. Early warnings of wildfires are to prevent fires from spreading in forested areas. WSN is used by this system for monitoring ambient temperature and CO2 in forests and provide warnings about forest fires.

Sheng Cao, Jingtao Xiao, "Forestry Fire Prevention Detection and Emergency Command System Based on Internet of Things and Infrared Light Sensing Technology [5]," forest fires not only cause a lot of damage to the forest, but also kill the animals in the forest, reduce the ability of trees to reproduce, lose soil and affect the water conservation of forests. Wildfires tend to burn over large areas and are difficult to extinguish, so it is important to put out the fire immediately, even though it is a small fire. Fires often occur in deep forests and jungles, and it is difficult to find fires, so early detection of fires is very important. Compared with building fire watch towers and video surveillance systems to prevent fire in forests, building early warning systems and understanding forest fire prevention knowledge and information in advance can detect and extinguish fires at an early stage.

Malti Gautam Singh, Sharini Rithigaa, Deepa Raj, Sharmila, "Forest Fire Detection and Prevention System Using IoT [6] ," uses a GSM module to design a low-cost and better detection and prevention system for forest fires. According to this proposed system, it easily detects forest fire in the first stage. In the monitoring system, the data obtained from the MQ-2 sensor and flame sensor will be transferred to the used hardware device. In other words, the MQ-2 sensor can detect methane, CO2 and smoke, and the flame sensor will detect if trees are on fire. The sensed data will be sent to the control unit. The received data will be displayed on the LCD screen and then sent to the GSM modem if necessary for the warning system to work.

Vivek,P .J Raju. G, Akarsh. S, "Forest Fire Detection System [7]," forest is considered one of the most essential and important resources of the world, and forest fires are a constant threat to ecosystems, habitats, and basic aspects of the environment. So, forest fire prevention and suppression is a very important issue. Furthermore, it is important to detect and prevent forest fires as soon as possible. This paper highlights the powerful features of wireless sensor networks as a solution for rapid forest fire detection. The data obtained from the sensors will be sent to a small satellite, and the data from the satellite will be analyzed and sent back to the ground base station. The proposed system based on these wireless sensor networks is designed to detect any fire hazard early and quickly.

May Zaw Tun, Htay Myint, "Arduino Based Fire Detection and Alarm System Using Smoke Sensor [8]," A fire detection system combines smoke, carbon monoxide and carbon dioxide as measurements at the same time. Fire alarm system includes fire extinguishers, control system and signal system. A fire detection system based on simultaneous measurement of ambient temperature and smoke have been developed. The alarm system included in the fire detection system detects flames that cannot be detected by the smoke detector. An alarm will be triggered when the sensed data exceeds or equals the threshold value. A fire alarm system constantly monitors fire indicators such as smoke or high temperature, so building occupants can be reliably alerted in time.

In this work, the data and information obtained from sensors on the environmental condition of the forest area will be implemented using the WSNs model. In addition, the data and information of the sensors will be stored on the cloud. Also, if there is a fire situation, the fire department will be notified in advance.

III. SYSTEM ARCHITECTURE

If the value of the sensing data obtained from the smoke sensor exceeds the threshold value, it signals the warning system that there is a lot of Carbon Dioxide (CO2) in the forest area. Depending on the condition of the forest area obtained by the weather sensor, the threshold value and condition should be checked. The value of the sensing from the temperature sensor exceeds the set temperature for the forest area to survive. The flame sensor is used to sense to the occurrence of fire.

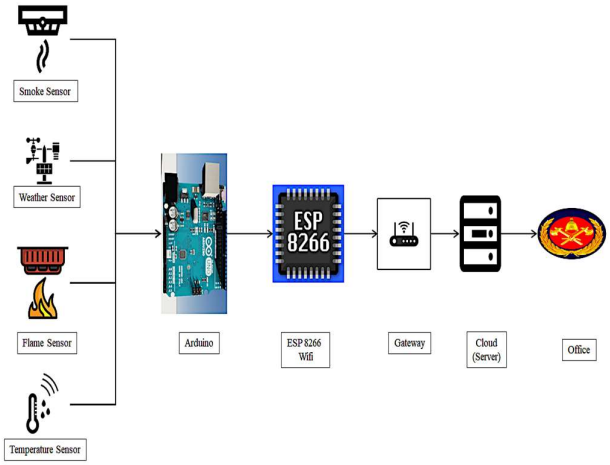

Fig. 1 System Architecture

Smoke Sensor (MG-811)

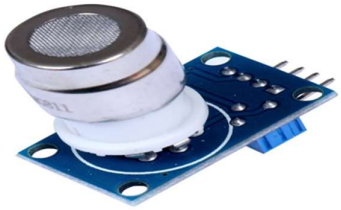

Fig. 2 Smoke Sensor

This module has MG811 onboard as a sensor component. There is an onboard signal conditioning circuit to operate the output signal and a heating circuit to operate the sensor. MG811 is highly sensitive to CO2, but only slightly sensitive to alcohol and CO. This sensor can be used for air purity measurement, fermentation, and indoor air monitoring.

Weather Sensor (WS800)

Fig. 3 Weather Sensor

It's a weather-sensing device that can learn about lightning currents. It is a weather sensor with professional intelligent measurement with digital interface for environmental applications. Integrated design with ventilated radiation protection for measuring: atmospheric temperature, heavy rainfall, rainfall pattern, amount of rainfall, sunlight availability, study of electric current, atmospheric pressure, wind direction and wind speed.

Flame Sensor (LM393)

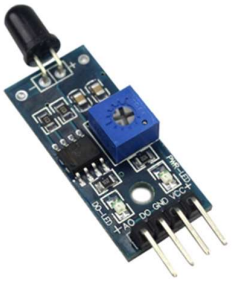

Fig. 4 Flame Sensor

LM393 flame sensor can usually detect flame. In general, normal lighting used for fire alarms and other purposes will also be flickering. The sensor is damaged due to high temperature, so keeping it at a distance from the flame will prevent the sensor from being damaged.

Temperature Sensor (DHT11)

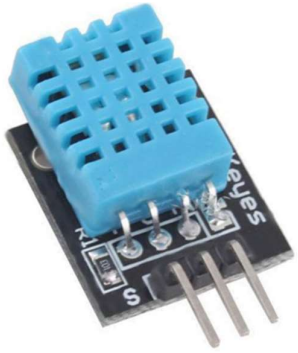

Fig. 5 Temperature Sensor

DHT11 is a digital optimized output moisture and temperature sensor. DHT11 can be inter-face to any microcontroller, such as Arduino and Raspberry Pi. DHT11 is a low-coast temperature and humidity sensor that offers high reliability and long-term stability.

Arduino ATmega 2560

Fig. 6 Arduino ATmega 2560

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins, 16 analog inputs, 4 UARTs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

ESP8266 WiFi Module

Fig. 7 ESP8266 WiFi Module

The ESP8266 WiFi Module is an enclosed SOC with integrated TCP/IP protocol stores that can commit any microcontroller to accessing your WiFi network. The ESP8266 is capable of either hosting an application or offloading all WiFi networking functions to another application processor. The ESP8266 module is an exceedingly cost-effective board with an enormous and ever-growing community.

IV. PROPOSED SYSTEM

The proposed system provides the monitoring and early warning for forest fire hotspot areas in our country. The general steps of the system are as follows:

- Step1: It is performing data collection from sensors.
- Step 2: Wireless node Arduino is connected with relevant sensors. Sensor data send gateway to the cloud (server) through ESP8266.
- Step 3: The Sensors data is received by Arduino and then transmitted to the ESP8266.
- Step 4: The Arduino received data and transmitted towards cloud (server).
- Step 5: The system compares with the received sensor values and threshold value. It is decided for two conditions such that.

  if (Received sensor value > threshold)
  then (SMS to the rescue organization)
  else
  No warning.
- Step 6: The system displays the relevant signal and send message to rescue organization.

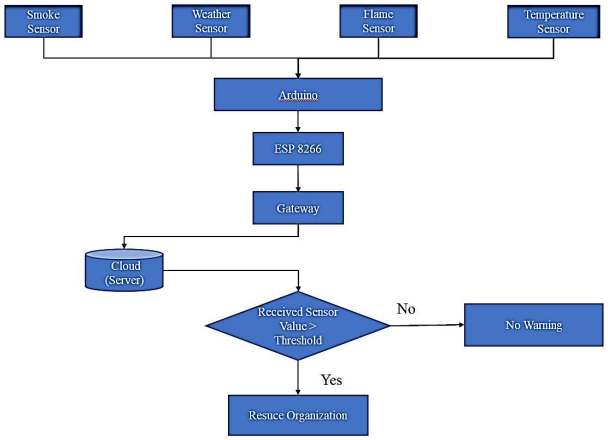

Fig. 8 Block Diagram Representation

V. RESULT AND DISCUSSION

Climate change is one of the major threats to cause the forest fire hotspots in Myanmar. The environment caused air pollution by forest fire hotspots. Due to whether natural disasters or man-made, for these events, it is necessary to have a forest fire hotspot monitoring and warning system that helps to reduce air pollution.

There is a need to be informed in advance of possible forest fire hotspots regions to minimize the effects of disasters. In order to inform rescue organizations with rapid speed of information, the system is need to monitor the situation that may cause a fire before the occurrence of forest fire hotspots.

All sensors collect the monitoring parameters such as temperature, smoke, flame, wind direction, speed of the wind. Monitoring parameters will be sent to the cloud and collected using ESP8266. And then, the monitoring parameters exceed threshold values. If a forest fire is detected, the system will send the alert sign and information related to the forest fire hotspots and rescue organization. This proposed system will be selected and worked in the densely forested Nay Pyi Taw Council area in Myanmar.

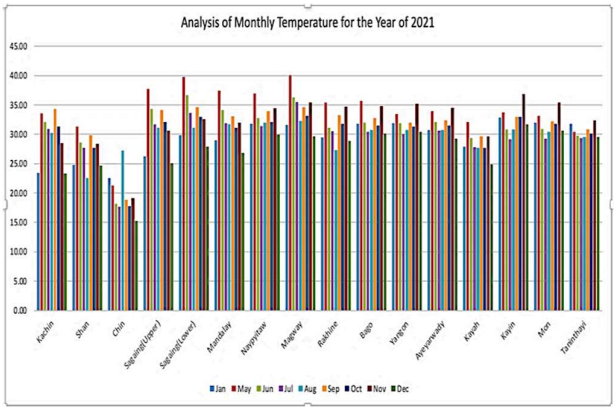

Fig. 9 Monthly Temperature of 2021

Fig 9: illustrates the actual monthly temperature data for the year of 2021. According to the analysis of Fig 9, it is observed that the temperature is high in some parts of Myanmar. It has been found that forest fires are more common in areas with such high temperatures.

VI. CONCLUSION

All in all, the proposed system uses the technology based on the wireless sensor network (WSN) can be provided for monitoring of the natural disaster with different parameters. The system assists the rescues organization to know information of fire areas according to the sensors data. Therefore, the system not only gives the efficient knowledge of the natural disaster to people but also reduce the air pollution and the serious damage of environment by disaster.

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