BOHR International Journal of Internet of things,
Artificial Intelligence and Machine Learning
2023, Vol. 2, No. 1, pp. 48–54
DOI: 10.54646/bijiam.2023.17
www.bohrpub.com

RESEARCH ARTICLE

Prevention of fire and hunting in forests using machine learning for sustainable forest management

S. Caroline[1*], J. Sam Alaric[2] and A. Anitha[3]

[1]Department of ECE, St. Xavier's Catholic College of Engineering, Nagercoil, India
[2]Department of EEE, Wollega University, Nekemte, Ethiopia
[3]Department of ECE, St. Xavier's Catholic College of Engineering, Nagercoil, India

***Correspondence:**
S. Caroline,
caroline@sxcce.edu.in

Received: 07 June 2023; **Accepted:** 28 July 2023; **Published:** 21 August 2023

Deforestation, illegal hunting, and forest fires are a few current issues that have an impact on the diversity and ecosystem of forests. To increase the biodiversity of species and ecosystems, it becomes imperative to preserve the forest. The conventional techniques employed to prevent these issues are costly, less effective, and insecure. The current systems are unreliable and use more energy. By utilizing an Internet of Things (IOT) system, this technology offers a more practical and economical method of continuously maintaining and monitoring the status of the forest. To guarantee excellent security, this system combines a number of sensors, alarms, cameras, lights, and microphones. It aids in reducing forest loss, animal trafficking, and forest fires. In the suggested system, sensors are used for monitoring, and cloud storage is used for data storage. Through the use of machine learning, the raspberry pi camera module significantly aids in the prevention of unlawful wildlife hunting as well as the detection and prevention of forest fires.

Keywords: forest fire, wildlife hunting, sustainable forest, sensors, deforestation

1. Introduction

All living things, including humans, are a part of the environment, which offers a variety of vital resources for survival. Consequently, it is crucial to protect the ecosystem. For instance, plants are the primary generators of oxygen, which is necessary for life to exist on Earth. Therefore, we must stop deforestation in order to save trees. Additionally, a number of animal species are endangered as a result of wildlife hunting.

The earth was covered with trees once. The amount of land covered by trees has substantially decreased as human population has grown and technology has advanced. Deforestation is the process by which forests and trees are lost due to the act of removing trees and forests. Typically, urbanization leads to deforestation. This however has a damning effect on our environment. Forests are home to 70% of all land animals and plant species.

A paucity of trees contributes to both the loss of habitat and the increase in greenhouse gas emissions. By removing carbon dioxide from the atmosphere, forests act as important carbon sinks. Trees help to control the water cycle, which in turn helps to control the amount of water in the atmosphere. In areas where trees have been cut down, less water can be recycled into the soil. As a result, agricultural cultivation becomes unfeasible due to the drying out of the soil.

1.1. Hunting wildlife

Hunting is a three-step process that involves finding, pursuing, and killing wild animals in order to trade, market, and financially get profit from their body and its parts. Hunting causes a lot of suffering to particular wild creatures. In addition to leading to extinction, overhunting has put a number of animal species in jeopardy (1). Migrating or hibernating animals that are hunted and killed develop a

fear of being killed, which may eventually make them to cease. Different species of both plants and animals suffer from the population decline brought on by hunting, which finally causes extinction. On the other hand, extinction has a significant negative effect on the health of the entire ecosystem because each species helps to keep our world habitable in some way.

1.2. Forest fire

Wildfire, sometimes referred to as forest fire, bush, or vegetation fire, is any uncontrolled and non-prescribed combustion or burning of plants that consumes natural fuels and spreads based on environmental variables in a natural setting, such as a forest, grassland, brush land, or tundra. Along with posing a threat to the entire regime of fauna and flora, they gravely harm the biodiversity, ecology, and ecosystem of a location. Climate-related factors, such as temperature, wind direction and speed, soil and atmosphere moisture content, and length of dry periods, are significantly responsible for environmental causes. It mainly destroys the environment, and hence, the forest fire affects the forest biodiversity severely.

The sun or a lightning strike might cause fire naturally, but most wildfires are ignited by reckless people. 84% of wildfires are ignited by unattended campfires, lighted cigarette butts, carelessly burnt garbage, and arson. Previously thought to be caused by lightning, wildfires are now understood to be caused by human error.

Stormwater runoff is the effect of forest fires that is most easily seen. The ground's soil changes after the absence of vegetation, becoming hydrophobic and preventing water absorption. Due to the incapacity to absorb water, debris and silt are encouraged to be transported into larger bodies of water, further contaminating important and necessary resources. Flash floods following a fire pose a risk and enable the introduction of heavy metals from ash and soil to reach waterways.

We can employ intelligent algorithms to identify forest fires, poaching, and deforestation before they occur in order to prevent these problems. However, the systems in use are outdated and cannot provide the user with correct data. We can precisely predict the data by Internet of Things (IOT). As a result, this endeavor is crucial for sustaining and monitoring the forest. These systems may also be far more effective than the ones in use now.

With the use of sensor and IOT technology, the Forest Monitoring System can be utilized to monitor a wide variety of terrain. It can be used to track the data uninterruptedly and continually. With the aid of machine learning, hunting and deforestation can be stopped. The thingspeak cloud assists in the ongoing monitoring of pertinent data such as forest temperature, humidity, forest fire detection, moisture content, rain detection, height checking, and so on. The raspberry pi is also cost-efficient and can be used for multiple purposes. The flame detector used detects the fire immediately.

1.3. Literature review

Deforestation and natural catastrophes have a negative impact on the forest environment in a number of significant ways. As background noise is analyzed by a classification algorithm, sensors are employed to monitor variables such as temperature, gas concentrations, soil humidity, and so on. Chainsaws, vehicles, and forest environment all make noise in the background. The forest guardian immediately notifies people in charge (by email, SMS, etc.) so that they can take action to halt the illegal destruction. An online application allows access to a map showing all dangerous regions. The user gets access to the collected data with the help of the Internet and a mobile application that permits warnings whenever fire, pollution sources, or illegal deforestation is discovered. An IOT project Sea Forest environment monitoring system was created with the help of public and private forest owners as well as national environmental and disaster response authorities (2).

A wireless sensor network-based system is used for monitoring forests and their surroundings to precisely monitor forest cover and quality (3). The monitoring of the forest and its surroundings, however, can still be regarded as an unsolved research issue because of its considerable size. Despite the fact that enough people have been dispatched, it is ineffective. Through the use of wireless sensor technology and the elimination of manual surveillance to the greatest extent possible, this prevents forest accidents, the entry of animals into the surrounding forest areas, and illegal activities in the forest.

To increase rainfall, lessen wind attrition, stem the tide of logging, and stop the encroachment of the desert, governments, particularly in semiarid regions of the world, designate tracts of woods as forest reserves. Forests are the third most significant natural resource on Earth after air and water. They effectively keep the atmosphere's gaseous balance by collecting carbon dioxide and releasing oxygen, which also helps to complete the hydrological cycle and produce rainfall. Food, medicine, timber, and many more goods can all be found in forests. They provide defense against things like radiation, drought, flooding, and soil erosion. The importance of forests in recreation and esthetics and as the habitat for a variety of wildlife indicates only a few of their additional roles. The main procedures that are crucial for forest monitoring including the detection of soil moisture, fire, human activity, and tree cutting (logging) are suggested. The initial step in the IOT-based forest security system is to gather sensor data from tree sites. Second, a Python-based system receives, processes, and analyzes, sends SMS,

and notifies concerned security personnel, staff members, or forest officers of the location of the impacted site (4).

Modern monitoring technology uses satellites to detect forest fires; however, this works when the fire is widely dispersed. These techniques are therefore no longer effective. According to a report, 80% of losses in woodlands are accumulated as a result of fires being discovered too late. A new approach to predict the fire at an early stage in order to overcome these two is presented. The hardware kit with a temperature and humidity sensor is connected to a computer and placed around the forest area according to the suggested approach. The information gathered by the sensor is uploaded at predetermined intervals. The cloud application is then used to upload these data. The fire alarm will sound if the temperature in the forest rises unnaturally, and the forest authorities will be notified. With the aid of machine learning, it can forecast future fires (5).

The environment has an impact on tree growth in artificial forest plantations, which is crucial for ensuring both quality and quantity. Earlier, the growth circumstances and information have been evaluated by experience. The ATmega 128L and CC2420 wireless node hardware chips are designed as the system's core and are integrated into a variety of sensors and modules for measuring tree growth, humidity, and temperature. Additionally, it completes the Z-Stack protocol stack's multisensor finite state machine program and enhances the composition of the gateway structure. Numerous experiments are used to gather the statistical data. The system is quite stable and supports IOT apps for monitoring forest data (6).

The benefits of trees include concealment and improved air quality. A strong, well-maintained tree is better equipped to survive weather conditions like ice storms, tropical storms, or strong gusts that can cause trees to fizzle. Protecting the trees is necessary to preserve the ecology. The intelligent forest system provides some safeguards to protect the tree from various dangers, such as unauthorized or illegal tree cutting, lightning-caused fire, internal fires, and nasty dirt. We can obtain the current state of the forest with the help of IOT. The IOT system offers better data efficiency and accuracy, which greatly aids in minimizing deforestation and other environmental issues (7).

The earth's forests produce air, soil, and climate cycles as well as support life. These ecological features support several industry sectors. The last 10 years saw the destruction of nearly 13 million hectares of forests, putting them in danger. Only a few nations have developed a similar smart forest system, which is required to offer monitoring and prevention for the forest. In comparison to conventional conservation, using sensors, a minimal wireless system, and renewable energy will produce energy that is more accurate, real-time, efficient, and easy to maintain. The system is made up of a camera, a grid of humidity and temperature sensors, fire and smoke detectors, and other sensors that are all connected to one another, each powered by a solar panel and lithium battery to form a mesh network. The microcontroller processes the data before sending them periodically to the monitoring server and giving warnings when a situation arises. Government agencies and even the general public can exchange and access the precautionary information (8).

Accidental forest fires are the most frequent type, and they can pose a serious hazard to both people and wildlife. The IOT technology connects devices, stores data, and enables objects to collect data for transmission through an Internet-based system. Here, smoke detectors, temperature, humidity, and ultrasonic sensors are utilized to detect the presence of fire and to gather data via the cloud in order to prevent urgent action and advance the system. In order to avert an accident, GSM sends an urgent message to fire fighters (9).

Knowledgeable investment, policies, planning, and monitoring the forest sector would be more advantageous for effective value of forest resources. Despite certain cutting-edge technologies, protecting trees in the forest's vast expanse is difficult. This study presents a system for monitoring forests and their surroundings that also prevents the trafficking of trees using a WSN-based IOT technology. Due to the size of the land, monitoring the forest and surrounding area is still difficult. Even with the deployment of enough troops, the problems with the forest could still be dangerous and ineffective. A WSN based on IOT has been tried for the prevention of forest accidents, animal infiltration in nearby areas, and illicit activities (10).

It is crucial to safeguard the ecosystem and the world. In the contemporary day, technology can be employed to create a favorable living environment by avoiding catastrophic failure. The effort is to form an IOT-based device with embedded autonomous capabilities that is able to recognize a forest fire as early as feasible and act quickly before it spreads and does significant damage. The suggested model integrates analytics as a service and provides intelligence at the peripheral. The model is constructed to combine autonomic aspects like self-monitoring and healing in order to achieve the ubiquitous environment that is created for a certain aim (11).

Internet of Things-based frameworks for monitoring the environment and climate change are now seen as being extremely successful. This research describes a framework that makes use of sensors to monitor forest conditions and quickly transmits the data to a server for prediction. In order to deal with and use them for the betterment of a Big Data condition, this investigation aims to explore the important structures for both batch and stream sensors. Big Data tools were used to handle, store, and display information for the IOT. Sensors for carbon monoxide (MQ 9), carbon dioxide (MQ 135), hydrogen (MQ 2), and methane (MQ 4) were evaluated during the experiment. They were connected with an Arduino-based microcontroller that supports the Transmission Control Protocol/Internet Protocol (TCP/IP) (12).

Forest fires worsen the forests and put species at peril. This paper offered a platform for intelligent early warning fire detection based on image processing. A real-time flame detecting system that distinguishes between fire and fire-colored objects is utilized to locate the actual fire incidence. Early detection of forest fires allows the IOT platform powered by the Raspberry Pi Microcontroller to take prompt action to put out the fire before it spreads to a large area. For forest monitoring, the Raspberry Pi-connected GSM modem alerts the control room. The image processing technology is connected to the GSM module and Raspberry Pi to identify forest fires as early as possible. It alerts everyone to the danger by sounding an alarm with a loud noise (13).

Environmental information acquired through real-time analysis of the environment may be useful for spotting or averting emergencies. Through IOT devices and sensors, it is now feasible to monitor a variety of environmental parameters, including temperature, humidity, pressure, and concentrations of harmful gases like carbon monoxide and carbon dioxide. Radical shifts in any of these variables, alone or in combination, may indicate unfavorable weather conditions that could cause a natural disaster like a forest fire. The real-time control of fire and tree-cutting events is possible with the IOT system proposed in this study. The suggested technology uses sensors and a microprocessor to spot potentially hazardous situations. Light and smoke are indicators of fire risk. The severity of the fire is indicated by a buzzer (14).

A wireless sensor network is made up of compact, multipurpose, low-cost, low-power sensor nodes. In a wireless sensor network, we deploy numerous separate nodes that each function on a different application based on the topology of the network. Each wireless sensor node is made up of different components, each of which has its own research focus depending on the needs of the overall system. The constrained energy resources of the sensor nodes and the environment may make it difficult for a wireless system for monitoring forest environmental conditions to be successful (15).

Because forest fire poses a major threat to forest resources and has an adverse effect on the ecosystem, protecting forests from fire is crucial for the survival of wildlife. This article uses vibration sensor, sound sensor, and fire sensor technology to recognize fire and numerous chemicals that cause forest degradation. A forest ranger can access the information before an odd scenario emerges by utilizing the MEMS accelerometer to detect vibrations created when tree branches rub against one another. The location is also recognized using GPS, and the information is communicated through the IOT. The current system uses multiple sensors, a microcontroller, a GSM module, and Zigbee to communicate information and warn the relevant party when the vibration sensor reaches a certain threshold (16).

1.4. Summary

The existing system cannot be used to detect the forest fire at the right time. Due to several lags in the system, the system does not have proper reliability. The efficiency is very less and also does not show continuous data, and as a result of this, monitoring of the forest and the environment cannot be properly done. The existing system needs continuous Wi-Fi connection, and as a result of this, the results cannot be obtained at the right time.

2. Proposed system

Six distinct sensors are employed in this system to perceive the forest. Since these data are connected to the cloud, we can continuously monitor the forests with the help of the Raspberry Pi and machine learning object detection algorithm. The thingspeak cloud data are updated every 15 s, allowing for the monitoring of the forest's temperature, humidity, altitude, and sea pressure. Using the fire sensor, the forest fire may be accurately detected. The camera module that is part of this system is also very helpful in stopping deforestation and animal hunting. For a specific forest area, the total number of sensors required is determined as follows:

$$\text{Total number of sensors needed} = \text{Area of forest covered} / \text{Range of the sensor.}$$

The Raspberry Pi contains a built-in camera module, which significantly lowers the system cost. It works like a tiny computer, making data searches more effective and pertinent. The system's machine learning algorithm significantly reduces the need for hunting and forest clearing. The Raspberry Pi camera module immediately sends any signs of deforestation or animal hunting to the system and warns the officers utilizing this system, creating a fantastic route to stop these unlawful activities. Deforestation and wildlife poaching can be reliably recognized since the object identification algorithm has a correct and accurate detection range. It continuously updates while monitoring the data.

Figure 1 shows the block diagram consists of six sensors, that is, a flame sensor, soil moisture sensor, temperature and humidity sensor, rain sensor, and barometer sensor, which are used for measuring various parameters of the forest environment such as temperature, humidity, altitude, sea pressure, soil moisture in the soil, and the raining condition. The bread board is used to transfer the various data from the six sensors to the Raspberry Pi's GPIO pins. The output and power supply are connected with a + 5 Vcc connection, and the ground pins are connected appropriately. The data from the Raspberry Pi are linked to the Thingspeak cloud. The Raspberry Pi python software is used to interface the field names with the data entered for each field. Each sensor is given a variable name in the Python program,

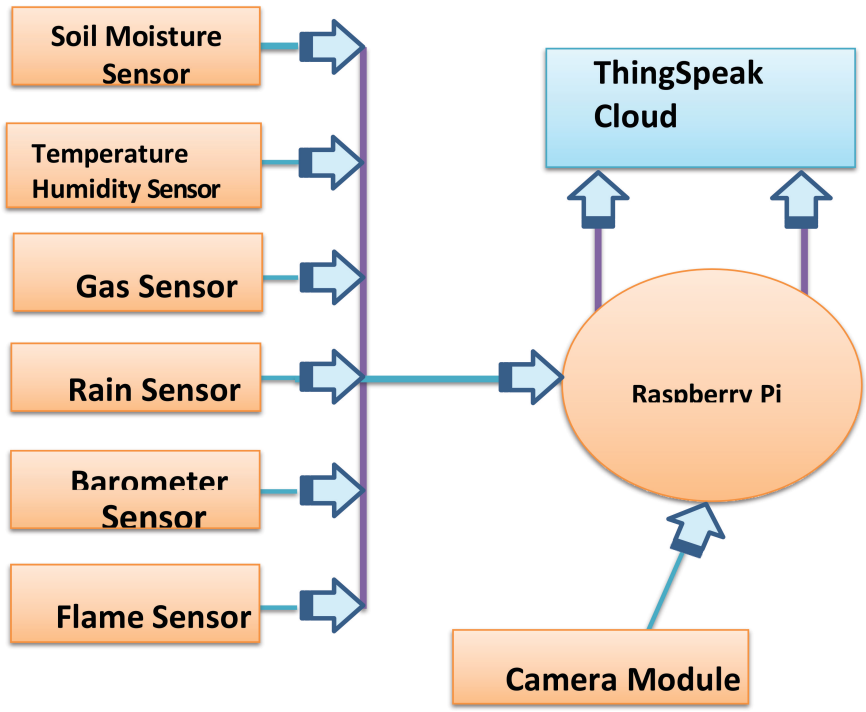

FIGURE 1 | Block diagram.

and the variable names are called using the define and call back function. Thus, the different parameters of the forest environment are continuously monitored.

Six sensors, namely, a temperature and humidity sensor, a soil moisture sensor, a gas moisture sensor, a barometer sensor, a flame sensor, and a rain sensor, are linked to the Raspberry Pi via a breadboard.

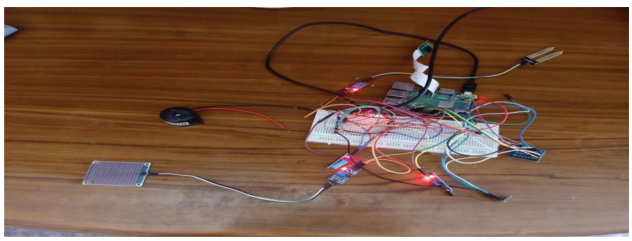

FIGURE 2 | Experimental setup.

3. Results and discussion

The different sensors are connected to the raspberry pi using the jumper cables, and the data are given to the thingspeak cloud. The overall experiment setup is highly cost-efficient, and each field datum is connected to each sensor. The overall experiment setup is given in **Figure 2**.

The buzzer is used to notify everyone when there is a forest fire, deforestation, or a wildlife hunt. For proper operation, the buzzer timing is configured in the Python application. A Python application performs the annotation, while another Python program stimulates the connections. The application written in Python for the Raspberry Pi simulates the outcomes.

3.1. Temperature field

The temperature sensor data are given to the Thingspeak cloud. The graph shows the recent temperature data which were recorded during 23rd to 26th of March, and it shows an

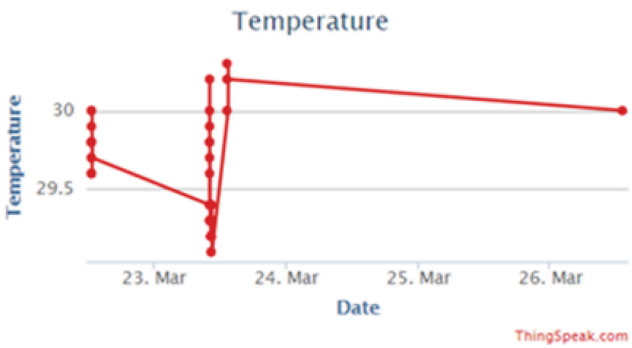

FIGURE 3 | Temperature field.

average temperature of 33 degree Celsius. The temperature field reading is shown in **Figure 3**.

3.2. Humidity field

The humidity sensor data are given to the Thingspeak cloud. The graph shows the recent humidity data which were

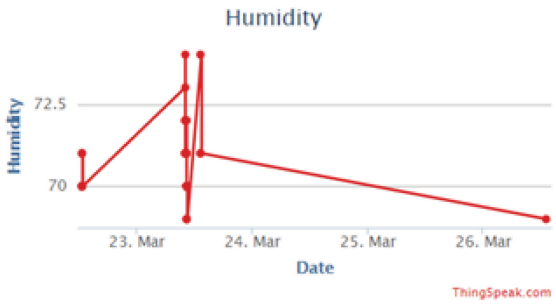

FIGURE 4 | Humidity field.

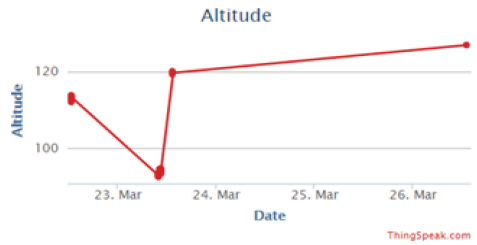

FIGURE 5 | Altitude field.

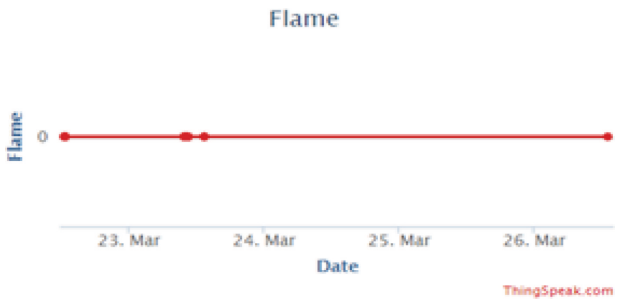

FIGURE 6 | Flame sensor field.

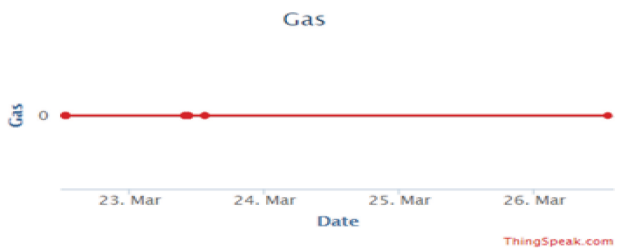

FIGURE 7 | Gas sensor reading field.

recorded during 23rd to 26th of March, and it shows an average humidity range of 75 on 23rd March and it slowly decreases and shows the lowest on 26th March. The humidity field reading is shown in **Figure 4**.

3.3. Altitude field

The altitude reading data are given to the Thingspeak cloud. The graph shows the recent altitude data which were recorded during 23rd to 26th of March, and it shows the altitude range of 100 to 120 on 23rd March and it slowly decreases and again increases and shows the highest on 26th March. The altitude field reading is shown in **Figure 5**.

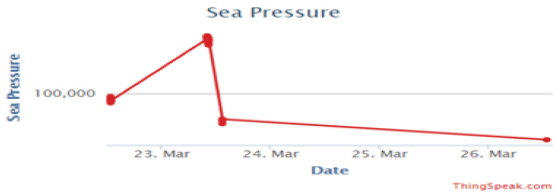

FIGURE 8 | Sea pressure reading field.

3.4. Flame sensor field

The flame sensor reading data are given to the Thingspeak cloud. The graph shows the recent flame sensor data which were recorded during 23rd to 26th of March, and it shows that there is no flame detected from 23rd to 26th March. If any flame is detected by the sensor, immediately, the data get updated in the cloud. The flame sensor reading field is shown in **Figure 6**.

3.5. Gas sensor reading field

The gas sensor reading data are given to the Thingspeak cloud, and these data are continuously updated for every 15 s. The graph shows the recent gas sensor data which were recorded during 23rd to 26th of March, and it shows that there is no gas detected from 23rd to 26th March. If any gas is detected by the sensor, immediately, the data get updated in the cloud. The gas sensor reading field is shown in **Figure 7**.

3.6. Sea pressure reading field

The sea pressure reading data are given to the Thingspeak cloud, and these data are continuously updated for every 15 s. The graph shows the recent sea pressure sensor data which were recorded during 23rd to 26th of March, and it shows that there is a great rise in the sea pressure on 23rd March and the value is dipped on 24th March and goes on decreasing up to 26th March. The sea pressure level is the average pressure level which is present in the sea, and it is greatly used in the prediction of the rainfall. The sea pressure level increases or decreases eventually with time, and hence, the sea pressure level plays a vital role in the forest monitoring and maintenance. The sea pressure level reading is shown in **Figure 8**.

The readings which are measured using the sensor are continuously monitored and are updated eventually in the cloud Thingspeak data server. These data are updated for

every 15 s. The sea pressure level helps greatly in monitoring the average rainfall in that particular area.

4. Conclusion and future scope

A novel approach to monitoring and sustaining forests that makes use of cloud data is very practical and senses all significant environmental factors, including temperature, humidity, height, and sea pressure. It accurately detects the flame and monitors the air quality, preventing future forest fires from occurring. With the aid of a machine learning system, it also stops deforestation and wildlife hunting. It has a variety of uses, including managing forest fires, control of air pollution, and monitoring of many air quality indicators in one place. It can be employed in areas with high levels of pollution as well as where deforestation and wildlife poaching are frequent occurrences. The camera may be used to watch the forest at any time, whether it is day or night, due to the great efficiency of the camera module. When compared to the current approach, the proposed solution is both more effective and significantly more affordable. Additionally, it is an entirely IOT system and more accurate. When compared to the current method, it is cost-effective.

Author contributions

All authors discussed the results and contributed to the final manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. Michael RC. Effect of hunting and trapping on wildlife damage. *Wildlife Soc Bull.* (2001) 29:521–532.
2. Alina-Elena M, Suciu G, Olteanu E. IoT system for forest monitoring. *Int Conf Telecommun Signal Process.* (2019) 2:629–632.
3. Syed Husai S, Vigneshwaran K, Kaveya S. Design and implementation of forest monitoring system using IOT. *Int J Adv Res Comput Commun Eng.* (2019) 8:136–140.
4. Purushottam RP, Patil VT. Smart forest: an IoT based forest safety and conservation system. *Int J Sci Technol.* (2020) 9:7286–7290.
5. Saranya N, Sahana S, Suganthi B, Vijaynigilesh RK, Vivin T. IoT based forest fire prediction and detection. *Int J Innov Technol Exploring Eng.* (2020) 9:1835–1838.
6. Yumjie X. Forest wireless monitoring system of internet of things based on Zigbee technology. *Inf Technol J.* (2013) 12:7631–7635.
7. Kaushik IP, Nair NJ, Bhavsar SC. Smart forest system. *Int Res J Eng Technol.* (2020) 7:3119–3124.
8. Denny D, Sirait DSP, Bay D. Sustainable smart forest monitoring system for burning forest and deforestation detection. *MATEC Web Conf.* (2018) 197:13023.
9. Parthipan V, Dhanasekaran D. Preventing and monitoring of framework for forest fire detection and data analysis using internet of things (IoT). *Int J Eng Adv Technol.* (2019) 8:691–695.
10. Sawsan S. Design and implemenation of IoT based forest monitoring and illegal tree cutting prevention system. *Sci Int (Lahore).* (2020) 32:207–210.
11. Niranjana R, Hema Latha T. An autonomous iot infrastructure for forest fire detection and alerting system. *Int J Pure Appl Math.* (2018) 119:16295–16304.
12. Sadman KM, Kamruzzaman SM, Ahmed A. Design and implementation of an IoT based forest environment monitoring system. *Int J Sci Res Technol.* (2019) 8:563–568.
13. Vidya A, Malini P, Sathiya SB. IoT based forest fire detection and early warning system using raspberrry Pi And GSM. *Int J Future Gener Commun Netw.* (2020) 13:1430–1435.
14. Saroja Devi H, Megha Shree J, Shruthi D. IoT based system for alerting Forest Fire and control of Smuggling. *Int J Adv Res Innov.* (2019) 7:91–93.
15. Sagar P, Asutkar GM. Review on forest monitoring using wireless sensor network. *Int J Innov Eng Sci.* (2019) 4:416–418.
16. Arul Stephen C, Vijaymalakshmi A, Ebenezer. Sensor based monitoring system for forest fire using internet of things. *Int Res J Appl Sci Comput.* (2018) 5:2099–2105.