IRJSE International Research Journal of Science & Engineering
*Int. Res. J. of Science & Engineering, Volume 11 (4) 2023*
ISSN: 2322-0015
SJIF Impact Factor 6.70
https://doi.org/10.5281/zenodo.8252509
RESEARCH ARTICLE
OPEN ACCESS

# An IOT Livestock health monitoring system for Farmers

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Manuscript Details
Received :04.07.2023
Accepted: 14.08.2023
Published: 16.08.2023

Available online on https://www.irjse.in
ISSN: 2322-0015

Cite this article as:
Sajid M. Sheikh, Thabang Tshepo Seloiso, Mooketsi Lesego Raiyo. An IOT Livestock health monitoring system for Farmers, *Int. Res. Journal of Science & Engineering*, 2023, Volume 11(4): 157-165.
https://doi.org/10.5281/zenodo.8252509



## Abstract

In many countries across the world, livestock plays a critical role to the economy as well as to the livelihood of people. In Botswana for example, livestock is a major agricultural sector contributing to 80% of total agricultural GDP. Livestock include mainly cattle, goats and sheep which can be of high value, especially those of special breeds such as boer goats and Kalahari reeds. Therefore, livestock health monitoring is very important to detect early signs of sickness, to allow for immediate removal of the animal from the heard as well as treatment. In this work an IoT system is developed to continuously monitor livestock temperature and heart rate and immediately notify the farmer owner throw a whatsapp message for any serious detections. The system utilized components like an LM35 temperature sensor to measure body temperature, and a KY-039 pulse sensor to determine heart rate. The system was integrated with the Thingspeak IoT platform through Wi-Fi, allowing data storage, analysis, and visualization in the cloud. The system developed is hoped to improve livestock health monitoring, treatment and farm management.

**Keywords:** ESP32, Heath monitoring, IoT, Livestock, LM35 Temperature Sensor, Pulse Sensor

## 1. Introduction

Botswana, an agriculturally based country that relies heavily on livestock, understands the importance of protecting the health and well-being of its goat herds. Many rural populations rely on livestock raising for revenue, food security, and employment possibilities.

Livestock monitoring is critical for ensuring animal well-being and productivity in agricultural contexts. Already existing research and technologies that use sensors, wireless connectivity, and Internet of Things (IoT) technologies has been able to allow for real-time monitoring and management of cattle and other livestock health [1].

The livestock sector in Botswana and in many other countries is divided into two, commercial and traditional/community farming. Livestock play a vital role in the rural economy in Botswana [2].

Livestock are prone to many health issues including viral infections, heat stress, and dietary deficiencies that can cause death if not treated ontime. Early detection of these health issues is critical for early intervention and effective treatment.

Much research is focused on the development of animal health telemonitoring systems [3]. However, the existing challenges and limitations of traditional livestock health monitoring methods in Botswana have underlined the need for a more efficient and technologically advanced approach.

Traditional livestock management systems have major obstacles in monitoring the health of livestock, particularly goats. The inability of livestock owners, farmers, and caregivers to successfully manage the well-being and production of their goat herds is hampered by a lack of real-time monitoring tools and timely detection of health issues. Furthermore, the lack of a comprehensive and integrated monitoring solution hinders the ability to rapidly identify and treat any health issues.

Current goat health monitoring methods rely mainly on manual observation, which can be time-consuming and prone to human mistake. The inability to continuously monitor vital factors such as body temperature and pulse rate results in delayed detection of health concerns, making preventive measures and prompt interventions difficult to apply. Furthermore, the lack of a centralized data management system inhibits efficient data analysis, making it difficult to identify patterns and trends that could inform better livestock management methods.

To address these difficulties, in this work an IOT health monitoring system is developed. The system allows for real-time monitoring of important indicators like body temperature and pulse rate, enabling early diagnosis and intervention of health issues. This will prompt treatment and can considerably lower the probability of disease spread, reduce animal losses, and enhance herd health overall.

## 2. Literature Review

Most farmers employ a manual method of detecting animal health-related disorders, which required continuous or daily observations, which requires an excessive amount of effort. Occasionally, such approaches yield incorrect results that differ from the actual health status [4].

Diseases affect goats in a variety of ways. These disorders can be detected using non-invasive, inexpensive, sensor technology [4]. These diseases can be linked to specific elements of animal behavior that have been linked to the most important sensors for detecting these diseases. As such if there are changes in the sensor data, this allows farmers to monitor the activity of goats and determine whether it is affected by disease.

Other times when the goats get sick, the farmers sometimes find it challenging to take them to the vet. In some cases, hospitals may not have any vets on staff. In those cases, various health parameters such as body temperature and heartbeat can be sensed, and a graph can be sent to the doctors using ESP8266 Wi-Fi module. So, by observing this graph doctors can talk about animal health, without having to physically examine them [5].

Seasonal and environmental changes can have a significant impact on the goats' health. Researcher [6] states that when goats are exposed to a hot environment, they are prone to suffer from heat stress which can negatively affect their feed intake and productivity as they decrease. As a result, the surrounding temperature and humidity must be regulated to keep the goats healthy.

Researchers in [7] specifically designed for a health tracking for heart rate and temperature of sick animals in a veterinary hospital. The system included web

application that focuses on monitoring these two vital signs. Whenever abnormal heart rate or temperature readings are detected, the system generates an alarm to alert the veterinary or pet hospital staff, indicating that the animal may be at risk and requires appropriate treatment. This system allows for the recording and analysis of health information from sick animals, enabling timely intervention. The advantages of this system are early detection of abnormalities and timely intervention.

The Authors of [8] describe the development of a smart animal health monitoring system based on the Internet of Things (IoT). The system focuses on real-time monitoring of physiological parameters, including body temperature, heart rate, and respiration, in addition to ambient temperature and humidity. The authors implemented a prototype using a Raspberry Pi 3 as the core controller, which includes built-in Wi-Fi capabilities. The Raspberry Pi processes the data collected from various sensors and displays it on a monitor, while also forwarding the data to the cloud. Users can access the information from anywhere using the internet and an Android app.

With a focus on head movements, core body temperature, and heart rate, researchers [9] presented a system for monitoring the health of cattle. An AMD186 processor mounted on a turn microcontroller board serves as the system's brain.

Other researchers such as [11] present a wireless sensor network system that tracks the vital signs of sheep and goats. The system utilizes wireless sensor nodes based on IEEE 802.15.4 technology, which are strategically placed to create a network of sensors. An algorithm was employed to detect instances of group stress in flocks of sheep and goats, specifically caused by nightly predator attacks. When changes in the vital signs of the animals are detected, the system sends an alarm signal to the person responsible for the livestock facility. Additionally, auditory and visual sirens are activated to scare off marauders and predators.

The author [12] presents a system design for healthcare on the Internet of Things (IoT) utilizing Raspberry Pi. The system employs a combination of Raspberry Pi and a GSM module to monitor various electrocardiogram (ECG) mechanisms for the detection of different types of cardiac illnesses. Python coding algorithms are used to analyze the ECG data and determine the presence of cardiac abnormalities. The resulting heartbeat data is automatically updated in a website database using the MySQLdv module. Additionally, Wi-Fi updates can be accessed through the USB 2.0 port, and the system includes an Ethernet port for network connection.

**Table 1: Showing summary of literature reviews.**

| Sensor Type used | System Description | Authors |
|---|---|---|
| • Temperature sensor<br>• heart rate sensor | IoT-based goat health monitoring system that includes a wireless sensor network, a cloud platform, and a mobile application. | [15] |
| • temperature sensor<br>• heart rate sensor | Automated IoT-based smart goat farming system that uses a wireless sensor network to monitor goat health. | [16] |
| • temperature sensor<br>• heart rate sensor | Smart goat farming system that uses IoT technology to monitor goat health. | [4] |
| • Accelerometer<br>• Gyroscope<br>• temperature sensor | Wearable device that attaches to the goat's ear and monitors the goat's activity, posture, and body temperature. | [17] |
| • Accelerometer<br>• GPS | Autonomous animal management system that uses accelerometers and GPS to monitor goat health and behavior. | [18] |
| • temperature sensor<br>• heart rate sensor | IoT-based sensing system that uses a wireless sensor network to monitor goat health. | [19] |

Researcher [13] demonstrates an Android application designed for geo-location-based health monitoring consultancy, incorporating an alarm system. The application allows for real-time remote monitoring of a patient's heart rate and geolocation tracking. It also includes decision-making capabilities for different alarm situations on smartphones and provides consultancy modules where users can seek advice from health experts. The prototype framework utilizes an Arduino Uno board and enables wireless transmission of sensor data (GPS sensor and pulse sensor) to the smartphone through a Bluetooth HC-05 module via a USB cable. The internet connection is established over cellular networks using 3G/4G wireless technologies.

The authors of [14], proposed a goat health monitoring system that focused on monitoring head motion, core body temperature, and heart rate. The system utilized various sensors and microcontrollers to capture and process the vital signs of the goats. The researchers explored different combinations of sensors and microcontrollers to develop an integrated monitoring system. Table 1 presents a summary of similar work.

In this work, we develop an IoT based that monitors livestock temperature and pulse rate, uses the ESP 32 micro roller, performs cloud computing as well as sends whatsapp notifications. Many systems do not have whatsapp notifications. The block diagram for the developed system is presented in figure 1.
A pet animal's core body temperature, specifically its rectal temperature, is a crucial indicator of its internal body temperature and overall health status. In the case of goats, their body temperature typically ranges between 39 and 40 degrees Celsius. If the measured body temperature falls outside this normal range, it often signifies an underlying health issue or abnormality that requires attention [20]. To accurately monitor the body temperature of the livestock, the LM35 temperature sensor is used in this work. The LM35 is a highly suitable temperature-measuring device because of its ability to provide precise and linear output corresponding to the body temperature. It operates by producing an analog output voltage that is directly proportional to the measured temperature. The LM35 sensor specifically provides the output voltage in the Centigrade (Celsius) scale, making it convenient to interpret the readings.

The LM35 temperature sensor has an impressive temperature range, rated to operate from -55°C to +150°C. This broad operating range ensures that the sensor is suitable for measuring temperatures within the normal physiological range of goats. The sensor's ability to accurately measure and convert temperatures into electrical signals eliminates the need for external calibration [21].

However, it is important to note that for accurate temperature measurement using the LM35 sensor, it needs to come into contact with the goat's body. This direct contact allows the sensor to accurately capture the animal's body temperature, providing reliable and real-time data.

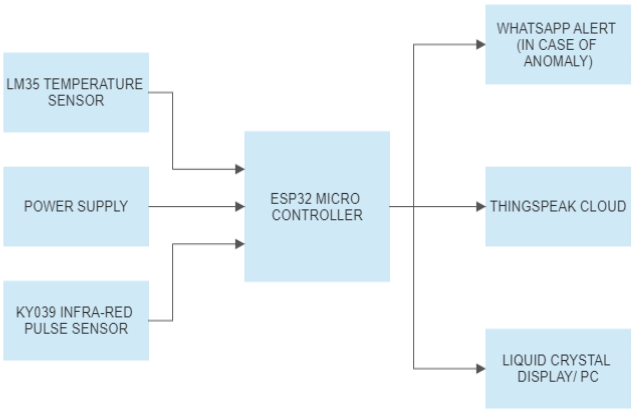


**Figure 1: System block diagram**

One notable advantage of using the LM35 sensor is its self-heating capabilities. This means that the sensor operates without requiring any external calibration or additional components to maintain its accuracy. The self-heating property of the LM35 ensures that the sensor can consistently provide precise and reliable temperature readings without the need for constant adjustments or recalibration. These features make it an ideal choice for monitoring the body temperature of goats, enabling the system to effectively detect any deviations from the normal temperature range, thereby facilitating timely intervention and appropriate care for the goats.

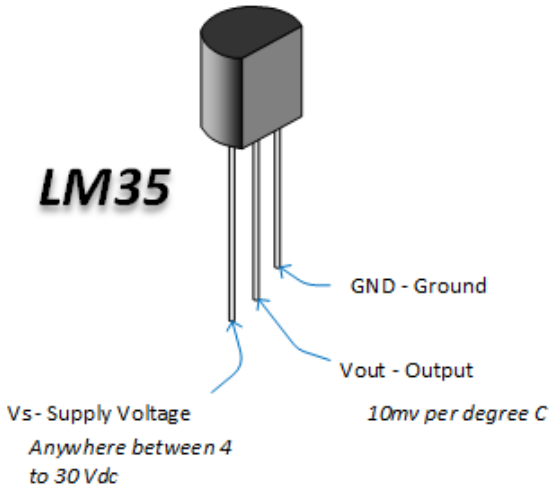


**Figure 2: LM35 temperature sensor**

The heart rate of a goat is a vital parameter in assessing its health status and overall well-being. It is typically measured in beats per minute (BPM) and serves as a reliable indicator of the animal's physiological condition [22]. In a healthy goat, the heart rate generally falls within the range of 70 to 90 beats per minute. Deviations from this normal range can signify stress, agitation, or potential health issues.

Measuring the heart rate is an essential part of monitoring the goat's health, as it provides valuable insights into the animal's cardiovascular function and overall stress levels. However, direct measurement of the heart rate through invasive methods, such as surgically implanting sensors, can be highly intrusive and impractical for routine monitoring.

To overcome this challenge, non-invasive methods are preferred for heart rate monitoring in goats. Non-invasive methods allow for the measurement of the heart rate without direct contact or any invasive procedures. These methods are typically more practical, convenient, and less stressful for the animal.

In the project, a KY039 Infra-Red (IR) sensor has been chosen to measure the heart rate of the goats. The KY039 sensor is specifically designed as a plug-and-play heart rate sensor, making it easy to integrate into the overall monitoring system. The sensor utilizes infrared technology to detect and measure the pulsatile flow of blood, providing an indirect measurement of the heart rate. The KY039 Infra-Red sensor operates in a non-invasive manner by sensing the infrared light reflected from the goat's skin. When the blood flow changes with each heartbeat, the reflected infrared light also fluctuates. The sensor captures these fluctuations and processes the data to calculate the heart rate in beats per minute. By utilizing the KY039 Infra-Red sensor, the product can accurately and non-invasively measure the heart rate of the goats. This allows for continuous monitoring of the goats' cardiovascular health, identification of irregularities or abnormalities in the heart rate pattern, and prompt detection of potential health issues or stressors.

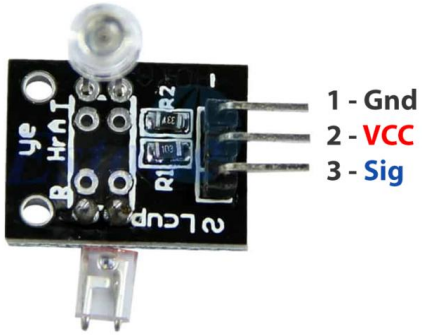


**Figure 3:KY039 Pulse sensor**

The ESP32 microcontroller is equipped with built-in Wi-Fi and Bluetooth capabilities, making it an excellent choice for wireless communication and connectivity [23]. This feature enables the microcontroller to establish a connection with external devices, such as the temperature sensor and heart rate sensor, and efficiently transmit and receive data.

The Thingspeak cloud is an Internet of Things (IoT) platform that provides a centralized and scalable infrastructure for collecting, analyzing, and visualizing data from connected devices [27]. In this project, the Thingspeak cloud was utilized to store and process the data collected from the LM35 temperature sensor and KY039 Infra-Red heart rate sensor using the ESP32 microcontroller. By utilizing the Thingspeak cloud in this project, the collected sensor data can be securely stored, analyzed, and visualized, providing valuable insights into the goats' health. Its scalability, real-time monitoring capabilities, integration options, and remote accessibility make it a robust and practical solution for managing and monitoring the goats' temperature and heart rate parameters.

A WhatsApp bot API is a programming interface that enables developers to create and integrate chatbots into the WhatsApp messaging network. This API provides developers with a suite of tools and functions that allow them to send and receive messages, automate responses, and execute other operations within WhatsApp conversations. It enables businesses and developers to build interactive bots that can interact with consumers, deliver information, answer questions, and do tasks via the WhatsApp messaging service [28].

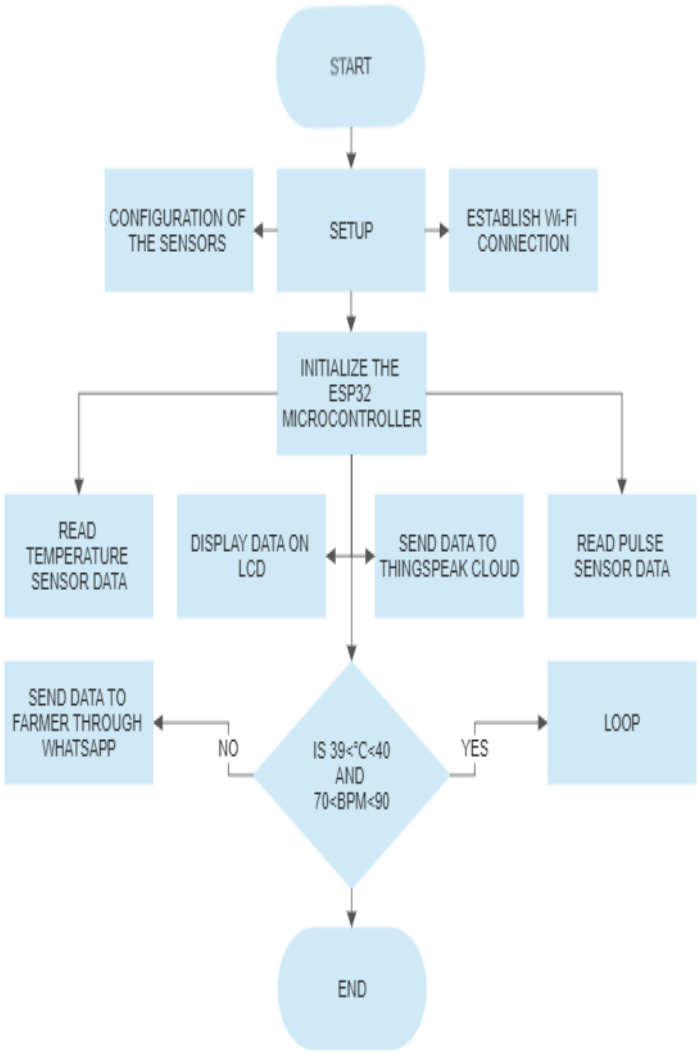


**Figure 4: System flowchart**

WhatsApp is a popular messaging application that allows users to send text messages, voice messages, make voice and video calls, share images, videos, documents, and more. It is available for smartphones and can be used on both Android and iOS devices. WhatsApp operates using an internet connection, either through mobile data or Wi-Fi, making it a cost-effective and convenient communication tool. WhatsApp is widely used for personal communication, but its features and accessibility also make it suitable for integrating with IoT devices, such as in this project. By connecting the ESP32 microcontroller to WhatsApp, real-time notifications and alerts can be sent to the farmer's WhatsApp account, providing immediate updates about anomalies in the goats' health and enabling timely intervention.

The flowchart for the operation of the system is shown in figure 4.

## 3. Result

The system prototype was successfully able to collect sensor data, such as body temperature and pulse rate, and deliver real-time data. By translating the analog voltage from the sensor into temperature values in Celsius, it delivered reliable temperature measurements. The temperature values were displayed on a 16x2 LCD screen before being transmitted to the Thingspeak platform for data logging.


**Figure 5: Output in Thingspeak showing Temperature and BPM graphs.**

The system utilized the CallMeBot API to send WhatsApp messages to ensure timely notifications and alarms. If the detected temperature exceeded a certain threshold (in this case, 30 degrees Celsius), a WhatsApp message with the current temperature measurement was sent to the supplied phone number. 30 degrees Celsius was set only for demonstration purposes since no goat was used, therefore in practice correct threshold values for can be set. The normal body temperature of goats is about 38.5 to 39 degrees Celsius. This feature functioned as an early warning system for monitoring the goats' health and taking appropriate actions.

Furthermore, Thingspeak, an IoT analytics platform, was used to capture and store temperature and pulse rate data. The ESP32 microcontroller talked with the Thingspeak server over Wi-Fi, allowing for smooth sensor data transmission and storage. A unique channel ID and API key were used to arrange the data, ensuring secure and trustworthy data logging.

## Conclusion

An IoT based livestock health prototype system that measures temperature and pulse rate, performs real-time data logging and sends whatsapp notifications has been developed. The final system will have to be built as a collar that fits onto the animal after study the animal behavior for the different livestock.

Besides health monitoring, farmers in Africa face many other challenges as well. These include poor to no commination networks in remote farm lands, no electricity, animal theft, heard boys being not literate, farm management and others.

The system can be enhanced by having GPS to track the animal locations to prevent thefts. Also battery management needs to be studied and batteries used in the system. Hence, it is important for the system to report units that are offline, so that these units can be physically inspected to determine the cause why they are offline. The use of such technology on farms will required trained staff.

**Conflicts of interest:** The author stated that no conflicts of interest.

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