Smart System for Monitoring Grain Stock

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Abstract - *Nowadays IoT has wide applications. In India, grain storage is found at the farm or village level in warehouses and godowns. Maintenance of atmosphere at the warehouses and godowns is essential. In India, due to atmosphere, insects and rodent up to 30% grain waste is going on at conventional storage houses. Grain wastage affects country's economy to a great extent. Hence proper maintenance has to be done so that the food grains remain edible. The proposed smart storage system uses different sensors to measure the levels of temperature, humidity, light intensity, methane gas and also a sensor to trace movements inside the godown which will help us monitor the atmosphere inside the godown. The proposed system is energy efficient, low cost, lightweight and portable.*

Key Words: **Sensors, NodeMCU, Adafruit IO, Arduino IDE, MQTT protocol.**

1. INTRODUCTION

India's rich and fertile terrain is home to a diverse range of landscapes, from mountains to deserts to delta flood plains. According to the World Economic Forum, the food produced in India's fields has a very high yield. Even then food self-sufficiency has already been achieved in the country. Despite its agricultural wealth, the country struggles to feed its own people. In the 2020 Global Hunger Index, India is ranked 94th out of 107 countries with a score of 27.2 [1]. The Global Hunger Index is a global study that evaluates and records hunger on a global, regional, and national level. The main cause of the disparity is agricultural food waste. Today, food preservations very important to fulfill the food supply chain needed by the developing countries like India. There is a huge need for preservation, protection, storage, distribution and consumption of food at later stage.

India failed to feed the poor and hungry during the covid crisis by letting the food grains rot in the godown. The foremost reason for this wastage is lack of storage facilities of abundant food grains. Because of storage of the food grains in such a sub-optimal conditions large amount of food grains were wasted. According to a survey, in just four months, between January to May , the stock of rice and wheat that was not "readily issuable", which included partially spoilt as well as damaged grain, increased from 7.2 lakh tonnes to 71.8 lakh tones [2] . This is more than the amount of grain that has been distributed through PM Garib Kalyan Ann Yojana in April and May to deal with the crisis of livelihoods and food insecurity created by the Covid- 19 lockdown.

As a result, grain farming and storage play a crucial role in the nation's economy and general social development. Economies of developed and developing countries rely on proper storage or proper cultivation methods either directly or indirectly. The quality of grain is affected by changes in the seasonal and daily environment, which can lead to an increase in mould growth and insect activity. Food grains stored in covered godowns undergo various preservation procedures such as fumigation and pesticide treatment. Despite measures, food grains may become unfit for use due to a variety of factors such as natural disasters or transit damage. Hence maintenance of atmospheric factors is essential. The main aim of this project is to design a smart system to keep track of grains stored in warehouses. The quality of grains is measured using temperature, humidity, light intensity and methane gas. The overall condition of the grains is updated to the maintenance people.

Over the past years, IOT has been introduced in agriculture for improving the efficiency of food production and transportation, but these technologies are not yet used for food security purpose stored at warehouse. The significant challenge facing the food security at warehouse is the interaction between the Security devices and to provide them intelligence to control other electronic devices to enhance the efficiency of food security at various warehouses. The main objective of this project is to preserve the food grains from rodents invading at warehouses and also threat to destruction of stored crops, due to variation in temperature, excess humidity, fire, theft, rain, flood, etc. So that stored food grains can be delivered as and when required (real time). In this paper we are integrating Internet of Things with sensors to improve the efficiency of food preservation in warehouse.

2. LITERATURE SURVEY

Grain stock monitoring system was implemented and proposed by several authors by different approaches. Shreyas S K [3] et al have proposed a system which aims to simplify the monitoring of food grains in remote towns of India. This paper has introduced a mobile app with which atmospheric parameters like temperature, humidity, smoke, humidity and light can be sensed and saved in database. All the sensed data is processed within the microcontroller and through GSM the output of microcontroller is sent to Android cell phone. A database is created to sustain data in local server using MySQL software. The proposed model uses DHT11 which is not as efficient as DHT22. GSM causes bandwidth lag if multiple users share same bandwidth. Kavya P et al [4] proposed a system using IoT technology, which is used to maintain the quality of the food grains over time. This system consists of components such as Raspberry pi3, Sensors (PIR, Temperature and Fire), Ultrasonic ranging device, Web camera, Buzzer and Android studio. All the sensors, camera and ultrasonic ranging devices are connected to GPIO header. The sensed data and the captured image of the object are processed in Raspberry pi3. Then same information is transmitted to the cloud. From cloud alert message is sent to the user. This system uses Raspberry pi3 which is expensive. Further the system can be improved to detect parameters like humidity, gas range. Ajay Doltade et al [5] developed a system, which effectively contributes in monitoring the conditions of the food grains by using DHT11, MQ2, MQ135 and PIR sensors based on IoT. The collected data from the sensors is provided as input to ThingSpeak database over cloud. Through Blynk application notifications are sent to maintenance people over time stamps. Notification is sent to limited number of people as only one person can access ThingSpeak IoT. Further the system would have been made more efficient by using NodeMCU microcontroller and DHT22 sensor. Susmita Banerjee et al [6] proposed a system which aims to reduce food loss by monitoring the status of the grains and increase food quality. Components used to implement the model are ESP32, DHT22, MQ-135, HC-SR501, KY-002, Fire sensor and Node-Red dashboard. The live data is presented on the dashboard using MQTT broker and can be checked at any moment by the farmers with aid of IoT. HC-SR501 is insensitive to very slow-motion objects and does not operate greater than 35 degree.

3. PROBLEM STATEMENT

In India, food production is seasonally in large scale, but the main problem is storage and ensuring food security is very important. Betterment of advanced production technology, grain production has been increasing gradually but the losses of food grains due to improper infrastructure services and adverse environmental conditions in storage is found at large scale. The warehouse lacks adequate ambiences such as proper temperature, moisture and light intensity which greatly affects the quality of grains and leads to damage and wastage of the product. The grain gets infested with moulds and insects due to lack of safe and scientific storage practices. According to WHO, disease-causing mycotoxins are found in mouldy grain/ foods. These releases toxins which have serious health implications and are cancer causing.

4. PROPOSED SOLUTION

The proposed storage management system uses the sensors like DHT22 (Digital Humidity and Temperature)to measure the levels of humidity and temperature, LDR (Light Dependent Resistor) to measure the light intensity level and MQ-2 gas sensor indicates the presence of methane gas which will help us to monitor the quality of the food grains. The system will reduce the wastage of food grain in godowns and cost for maintenance of grain storage.

5. METHODOLOGY

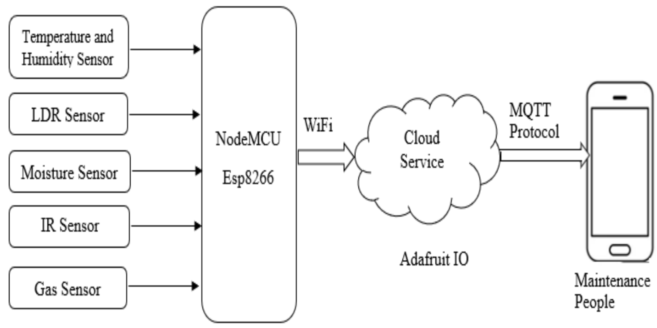

Fig -1: System Block Diagram

The system block diagram is as shown in the above Fig- 1. The first unit of the system is the sensor unit which comprises of different sensors to measure different parameters. It consists of a DHT22 temperature and humidity sensor to measure real time parameters such as temperature and relative humidity inside the godown. An LDR sensor is used to measure and monitor the intensity of light. A moisture sensor is used to detect the moisture inside the godown due to leakage of water, which is affected because of heavy rainfall or flood, as this moisture content will lead to decaying of food grain. The system also consists of IR sensor to detect the movements inside the godowns. Along with these sensors an MQ-2 gas sensor is used, which will measure the methane gas level emitted by the decayed food grains, or in other case this gas sensor along with DHT22 sensor can be used to detect fire inside the godowns. The sensed data is processed by the NodeMCU microcontroller and all these measured parameters are transmitted to the cloud service using ESP8266 wifi module. The Adafruit IO acts as a cloud service, all the measured data will be published in Adafruit IO and through MQTT protocol it alarms maintenance people about the condition of the food grains.

6. SYSTEM REQUIREMENTS

6.1 NodeMCU ESP8266

NodeMCU is an open source IoT platform. It contains software running on Espressif Systems ESP8266 Wi-Fi SoC, and hardware based on ESP-12 module. The firmware utilizes the Lua scripting language. NodeMCU is shown in Fig-2 and Table I provide its specifications.

Fig-2: NodeMCU ESP8266

Table -1: NodeMCU Specifications

Specifications	ESP8266
MCU	X-tensa Single core 32- bit L 106
Frequency	80/160 MHz
RAM	32KB
Flash Memory	200KB
GPIO	17
ADC	10 Bit
SPI/I2C/I2S/UART	2/1/2/2
802.11 b/g/n	Yes

6.2 DHT22 Sensor

The DHT22 sensor is a three-pin digital sensor for temperature and humidity measurement. It runs with 3-5 V power, a low-cost device, excellent for laboratory calibrated humidity measurement with an accuracy of 2 to 5% in the range of 0-100% humidity and can measure temperature within the range of -40 to 125°C with ±0.5°C accuracy. DHT 22 sensor is shown in Fig-3.

Fig-3: DHT22 Sensor

6.3 MQ-2 Gas Sensor

The MQ-2 gas sensor is an electronic sensor that detects the presence of gases such as LPG, propane, methane, hydrogen and carbon monoxide in the air. In detecting gas levels between 200 to 10000ppm, the sensor is extremely sensitive. The output of the sensor is analog resistance, which must be calibrated to ppm. MQ-2 gas sensor is shown in Fig-4.

Fig-4:MQ-2 Gas sensor

MQ2 Gas Sensor Calibration:
In the following eqn.(1) the analog resistance value is converted to the voltage equivalent value

Sensor Voltage = (Analog Resistance Value / 1024) * Vcc ----(1)

Rs = (Vcc – Sensor Voltage) / Sensor Voltage ----(2)

Where,
Rs is the resistance of the sensor that changes depending on the concentration of gas.
Ro is the resistance of the sensor at a known concentration without the presence of other gases, or in the fresh air.

For air, Rs/Ro = 9.8 for MQ2 gas sensor. By comparing Rs/Ro with PPM in the sensitivity curve given in the MQ-2 data sheet [7] the calibrated gas concentration in ppm is determined.

6.4 IR Proximity Sensor

The IR Proximity Sensor is a multipurpose infrared sensor that can be used for obstacle detection, color detection, fire detection, line detection, and encoder sensing. To read the sensor data, this digital output can be directly connected to an Arduino, NodeMCU, Raspberry Pi, AVR or any other microcontroller. Digital output is provided by the sensor. IR proximity sensor is shown in Fig-5.

Fig-5: IR Proximity sensor

6.5 Light Dependent Resistor (LDR) Sensor

A Light Dependent Resistor is (LDR) is also called as photoresistor or a cadmium sulfide cell. It is a photocell which works on the principle of photoconductivity. The device output is a resistance value, which needs to be calibrated in to unit of light i.e., lux (lx)[8].
NodeMCU can sense lowest value of voltage 0.0048828125, obtained by dividing the supply voltage of 5 volts by total number of analog levels 1024.

Least Step Voltage = 5 / (1024 Steps)
= 0.0048828125 ----(3)

Resistance value is converted to equivalent voltage value by multiplying Least Step Voltage with sensor resistance value.

Voltage = Least step voltage x Sensor resistance ----(4)

Finally intensity in lux is determined by the eqn. (5) below,

Intensity = (((2500/ voltage) – 500) / 10) lux ----(5)

Fig-6: Light Dependent Resistor (LDR)

6.6 Moisture Sensor

In this project, the moisture sensor is used to detect the moisture content in the warehouses so that during heavy rainfall, when there is leakage in the warehouses the moisture content is sensed and alarmed about the same to the maintenance people.

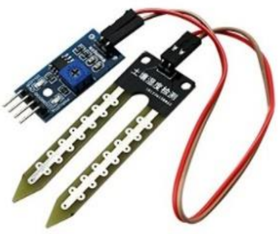

Fig-7: Moisture sensor

6.7 Adafruit IO

Adafruit IO is a powerful, easy-to-use IoT platform for organizations that helps to develop complicated systems quickly and securely. In order to link between one and millions of devices Adafruit IO use open communication protocols, such as Message Queuing Telemetry Transport (MQTT). In order to analyze and quantify large quantities of sensor data, Adafruit IO includes sophisticated data gathering, collection, and visualization tools.

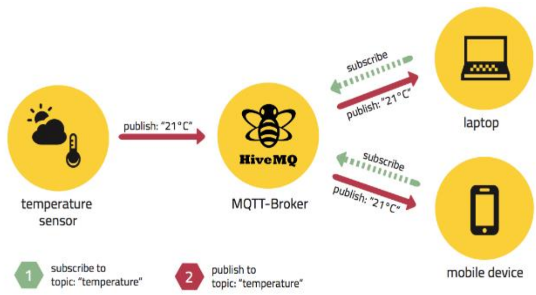

Fig-8: MQTT Protocol

7. RESULTS

The data from the sensors is sensed, processed, and is communicated by Node MCU. The measured data from the sensors is sensed and uploaded to NodeMCU by programming in Arduino IDE. Once the code is executed the results of all the measured data is displayed in Arduino IDE as shown in the below Fig-9.

```
Sending Sensor's Value Sensor 1 26.90
...OK!
Sensor 2 76.90
...OK!
Sensor 3 624
...OK!
624
Smoke detected
Sensor 4 1
...OK!
Object is not detected

Sending Sensor's Value Sensor 1 26.90
...OK!
Sensor 2 76.80
...OK!
Sensor 3 625
...OK!
625
Smoke detected
Sensor 4 0
...OK!
Object detected
```

Fig-9: Output displayed on Arduino IDE

The screenshot of results from Adafruit IO is as shown in Fig- 10. In order to display the results of the sensed data by the sensors, several indicators can be used. The data from the Node MCU is later published to Adafruit IO through WiFi. Here Node MCU acts as a publisher and will publish the sensed data to Adafruit IO. The farmers and the maintenance people have to subscribe to this user to access the data. The live updates can be checked anytime by viewing into Adafruit IO website. Here in order to display the value of temperature, humidity, gas level a gauge has been placed, which will indicate the amount of sensed data. A Boolean indicator has been placed to indicate the movements inside the godowns.

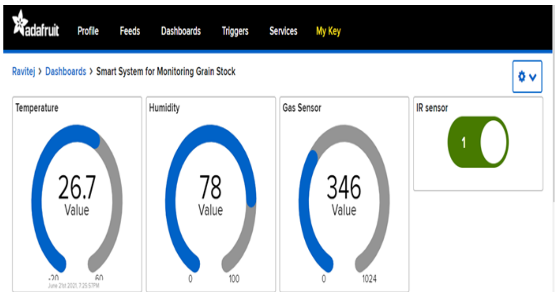

Fig-10: Sensors data displayed on Adafruit IO

By using Adafruit IO cloud service the published data is available both in website and MQTT Dashboard mobile app. The farmers and maintenance people can access these measured data by installing MQTT dashboard Mobile application. The results displayed in the MQTT Dashboard are as shown in the Fig-11.

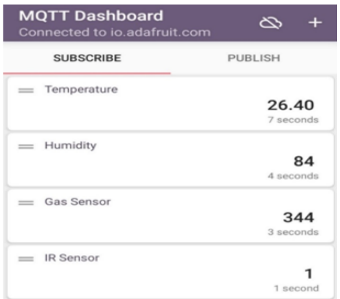

Fig-11: MQTT Dashboard Mobile App

8. CONCLUSION

This smart system helps us to overcome the drawbacks of traditional approach of grain storage practices. The system is flexible and reliable to access the status of the stored grain by interfacing various sensors with NodeMCU. We can efficiently monitor the environment parameters and can prevent decaying and rotting of food items. With completion of the system, stored grain losses may effectively be reduced to 80%.

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