A Study of an IoT Integrated Sensor Network Model for Agricultural Data Collection and Data-driven Instruction Providing System for Precision Farming in Bangladesh

***Abstract*— In recent years, the internet of things (IoT) already has many positive impacts on agriculture. With the adoption and support from the IoT in the agricultural sector of Bangladesh will not only ensure the higher crop growth but also give farmers the opportunity to monitor soil condition and simple weather forecast. However, Bangladesh is a land of fertile soil and a riverine country and contribution of the agricultural sector in GDP of Bangladesh is also very remarkable, due to the lack of technology adaptability in the agricultural sectors farmers of this country are becoming vulnerable to many problems that limit their ability to enhance agriculture production and their livelihoods. This study is designed to provide farmers the information about the condition of soil with the help of different sensors and highlight the relevant instructions with the weather forecast to take necessary steps. This research would contribute to the farmers as well as the agricultural officers to meet the challenges as well as take the initiatives for better and quality agricultural products.**

***Keywords*— IoT, sensors, temperature & humidity sensor, P^H sensor, weather alert, Ultrasonic pest repellent.**

I. Introduction

Since the land of Bangladesh is very fertile, hence proper care should be taken to grow crops and vegetables. Therefore, information about soil is needed to use proper fertilizers depending on alkalinity and acidity of the soil. Currently in Bangladesh, the farmers and agricultural officers need to send the samples of the soil to SRDI (Soil Resource Institute) to collect the information [1]. To avoid this time consuming process, a model incorporated with facilities of the IoT and various sensors has been designed to collect the pH value of the soil and after analyzing the collected data it provides instruction of the proper fertilizers to be used.

Moreover, weather forecasting is also essential regarding sowing seeds and to prevent vegetables and crops from fog and rain with hailstones. In order to forecast weather, a study of the previous four years on meteorological report of Dhaka city was carried. By setting an algorithm based on the data from sensors, weather forecast of the vicinity can be possible and it has been done accordingly. All this information can be inherited by simply calling the system by cell phone by a farmer or agricultural officer and after receiving an SMS, which contains the instructions and data from the sensors. Therefore, a good and proper decision can be taken based on the information. These data can also be visualized in a web server, which can be accessed remotely by agricultural officers and farmers as well. The access can also be varied from public access to private access. From the server, data can be exported for further analysis. This feature enables the model to enter into the realm of IoT. A group of model will definitely empower government to collect data from various fields simultaneously to visualize the condition of soil of several lands centrally at the same time it will also allow them to get data for further research and analysis. In addition, with the help of this IoT feature instructions from agricultural office can be forwarded quickly and decision regarding farming can be taken quickly as well.

Furthermore, Protection from some harmful pests can be achieved with the help of ultrasonic sound. Therefore, less pesticide is needed and people can get healthy harvest. Utilizing less pesticide will eventually reduce the increasing resistance capability of pest against the pesticides. Consequently, our environment will be benefited. We came to know that Bangladesh grows surplus vegetables though they cannot be exported due to quality issues are involved [2]. This system would help farmers to grow quality vegetables which will pass the test associated with the standard for export and eventually that will contribute to bring a significant change in the economy associated with agriculture.

II. Design and System Overview

Involvement of IoT (Internet of things) in agriculture gives the opportunity to monitor the soil quality and maintain good harvest throughout the year. Moreover, it also allows people to gather a huge amount of agricultural data for analysis and research. Furthermore, IoT implementation of monitoring and controlling various operations remotely, benefit people in terms of smart farming. In order to achieve precision farming, IoT plays a decisive role, which is a rewarding contribution towards the agriculture-based economy. According to some published research, ultrasonic pest repellent assists in reducing the use of pesticide. Since ultrasonic frequency not only repels but also affects the reproduction of some harmful pests within a certain range[3]. Therefore, an IoT incorporated design equipped with essential sensors and ultrasonic pest repellent will definitely improve the quality of farming among the countries where agriculture plays a vital role in the economy.

The system of the model has been divided into different units. The major units of this project are microcontroller unit, Power unit, Sensor unit, pest repellent unit, Display and GSM or Communication unit. A block diagram regarding the different units and their dependability with each other has been illustrated in figure 1.

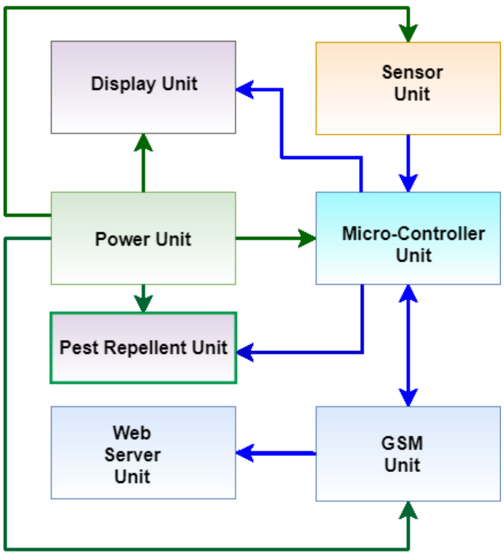


Fig.1. Power and signal distribution Units.

Power unit is responsible for providing the supply of the power to all the units. Sensor unit is connected both with power unit and microcontroller unit. All the data are processed in the microcontroller unit and sent through GSM unit to the appropriate destinations. The function of the sensor unit is to sense the ambient temperature, humidity, light intensity and the pH of the soil. Display unit only receives the commands from the controller unit to display current temperature, humidity, pH value, light intensity and provide instructions accordingly. Here, GSM module receives commands and data from the controller unit and sends data to the server to update remote database. GSM unit is also accountable to send SMS to the farmers and agricultural officer.

For the construction of the model, Arduino Mega 2560 has been used, which is an open source microcontroller device [4]. Block diagram for the study, model structure is shown in figure 2. This block diagram is comprised with solar panel, rechargeable battery, microcontrollers, sensors, LCD display and GSM module. Powered by the battery, the Arduino Mega 2560 (Microcontroller unit) collects all the sensor values and continuously display the values on the 16×2 LCD display unit. As it has been illustrated in the block diagram, the Arduino is also connected with the GSM module, which is functioned to send the sensor values to agricultural officer as well as to the farmer. A NodeMCU (ESP 8266 Wi-Fi Module) is also used beside GSM module as a backup communication method.

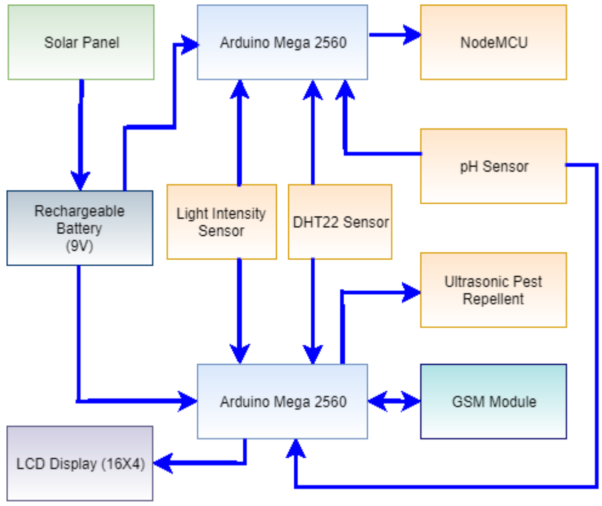


Fig.2. Functional block diagram of proposed model.

III. Hardware Implementation and Model Overview

Microcontroller unit (Arduino Mega 2560) was powered up by a 9 V 220 mA battery which also provide power to the GSM module. DHT-22 sensor was selected as the temperature and humidity sensor by which dew point temperature also can be achieved. P^H sensor, Light Intensity sensor, Ultrasonic sound emitter and GSM module are connected with Arduino. Additionally a Wi-Fi module was also used beside GSM module for communication.

As all the devices are connected and powered up, sensors collect the respective values and after processed by microcontroller unit; the values were displayed on the LCD display. P^H sensor measures the ^{pH} of soil and gave required instruction based on the algorithm. This algorithm was made with the help of some conditions, which is shown in Table 1. DHT22 sensor collects the humidity and temperature data and returns calculated dew point temperature and heat index based on temperature and humidity values. Light intensity sensor measured the light intensity and returns the intensity data. Analyzing the sensor values some instructions and forecast are provided. Then according to the proper condition and algorithm programmed to the microcontroller unit, some instructions for the farmer appear on the display correspondingly. After that, maintaining a delay the microcontroller unit sends the values with the help of GSM module/Wi-Fi module to a server for further access for data and analysis. If the farmer and the agricultural officer are registered with the project then the values can also be sent to their registered cell phone as SMS, maintaining a delay. Thus this model establishes an IoT integrated sensor network for agricultural data collection.

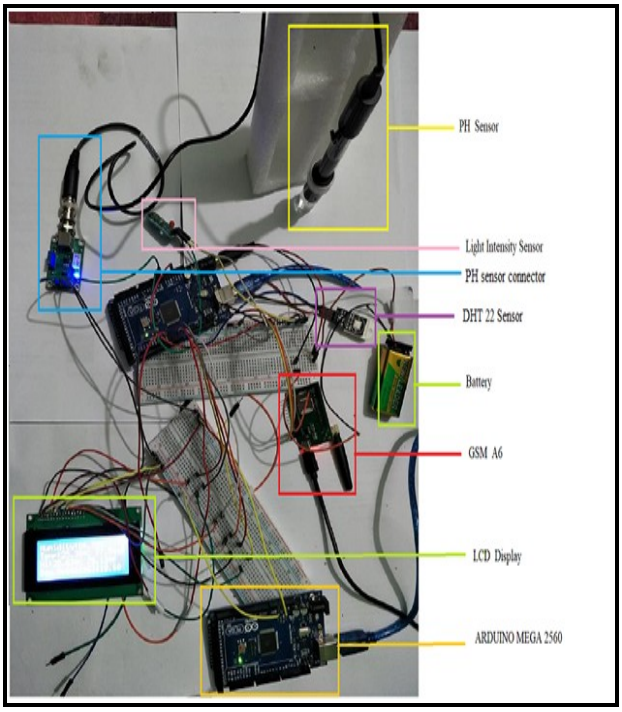


Fig.3. Hardware Implementation for testing.

By observing and analyzing the several years of weather data of Bangladesh, conditions have been made just looking into three parameters [5][6]. The condition for weather prediction is shown in Table 1. These three parameters are temperature, humidity and dew point temperature.

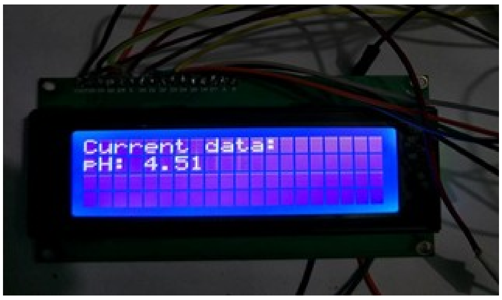
TABLE I. CONDITION TABLE FOR WEATHER PREDICTION

Temperature °C	***Humidity %***	***Dew Point Temperature °C***	***Forecast***
6 to 18	65 to 85%	10 to 16	It will Fog
19 to 40	65 to 100%	22 to 28	It will Rain
Else	Else	Else	The weather will be Clear

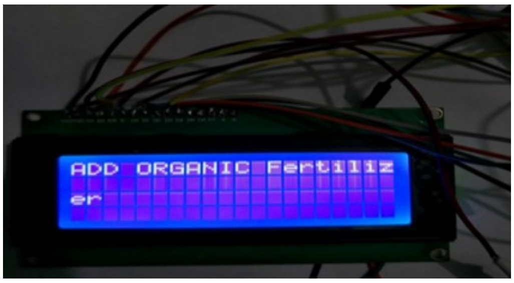
IV. RESULTS

A. Result Visualization

To measure pH value, a solution mixed with pure distilled water was prepared. Each time the pH sensor provides a value for the solution which ranges from 1 to 10. It is tested that when the pH level is less than 5.5 the soil is extremely acidic and required to take appropriate measures [7] [8]. In the lab, the obtained pH value was less than 5, so the soil was determined as acidic; hence the instruction appeared on the LCD display states "Add Organic Fertilizer". If the soil had been alkaline, pH value would have shown higher than 7 and the instruction would have shown "Add Urea Fertilizer". This is the way how appropriate instruction appears on the LCD display and in SMS as well (Figure. 6(e)). Figure 4(a), 4(b) shows the pH value and appropriate instruction.



(a)



(b)

Fig.4. LCD display output of (a) pH sensor value and (b) appropriate instruction regarding soil P^H.

Light intensity was measured with the help of Light Sensor Module. If the value of light intensity sensor is less than 300 lux then the weather might be cloudy or foggy or it could be night [9]. DHT22 sensor provided the ambient temperature and humidity through the analog pin on Arduino Mega. According to the conditions from Table 1, the LCD displayed predicted weather shown in Figure.5 (b).

(a)

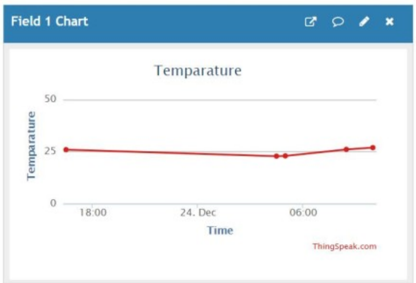
(b)

Fig.5. LCD display output of (a) DHT22 sensor and (b) appropriate weather forecast.

B. Data visualization in Server

To analyze, visualize and monitor real time data, ThinkSpeak has been used which provides the platform for IoT analytics service [10]. Figure 6(a), 6(b), 6(c), 6(d) respectively shows temperature, humidity, dew point temperature, pH value from the ThinkSpeak.

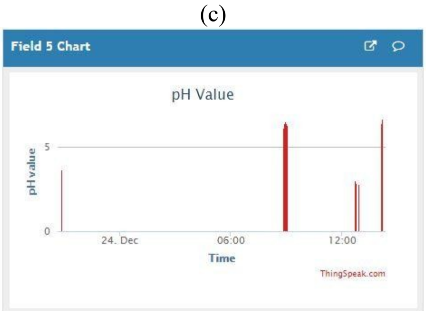
An SMS was sent to the cell phone which was generated by the GSM module following a delayed time period. Figure 6(e) shows a screenshot of mobile screen showing SMS was sent from the system which contains all the sensors value and appropriate instruction and forecast as well.



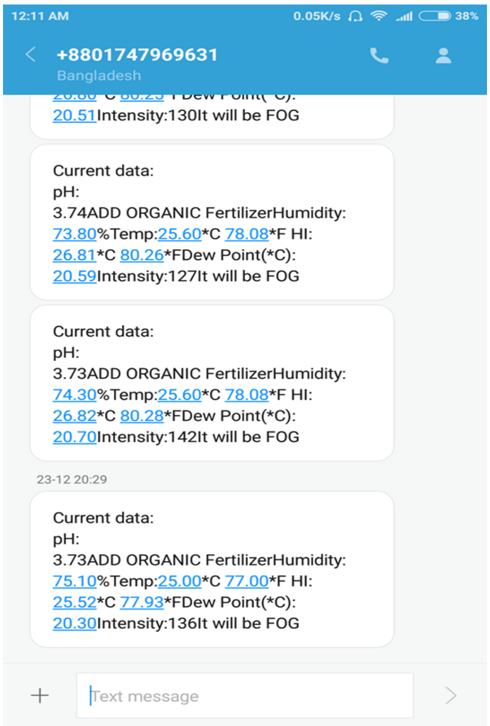
(a)

(b)

(c)



(d)



(e)

Fig.6. Graphical representation of (a) temperature, (b) humidity, (c) dew point temperature and (d) pH value at ThingSpeak and (e) screenshot for received messages.

V. Conclusion

This study has numerous advantages, which makes it closer to smart farming. GSM technology is quite reliable, which was accountable for sending data automatically. Therefore, if anyone lost internet connection for any reason, they will still be able to get the data with the help of GSM technology. This makes this a reliable design in the scenario of a developing country. Besides farmers, agriculture officers can also be benefited since they are getting the information of the soil without visiting many fields. That would save their time and they can be engaged in more productive work. The model also has an opportunity to add various types of sensors beside the sensors used in this study. In addition, if multiple models are implemented in various fields, it will send a huge amount of data in the web server, which will open a new door for data analysis and research regarding development. Moreover, agriculture officers from their office can monitor many fields within a very short time. This approach will definitely enrich the FIAC (Farmers information and advising center) of Bangladesh. Eventually, this can make a centralized agricultural field monitoring system for the Ministry of Agriculture in Bangladesh.

Furthermore, considering the environmental impact of chemical pesticides, this ultrasonic sound has better influences. Not only it saves our health from the harmful effects of chemical pesticides, but it also saves the environment from the pests being resistant to pesticides and saving the environment as well.

In this millennia, precision and quality farming is not only today's necessity but also obligatory to meet the demands of the rising modern population. Introducing the IoT into agriculture gives the opportunity to produce healthy crops and creates the research and development facilities with access to vast amounts of practical data. This study would open the door to let Bangladesh as well as other developing countries to enter into the realm of smart and quality farming.

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