Indian Journal of Ecology (2020) 47 Special Issue (11): 236-240

Manuscript Number: S-421
NAAS Rating: 4.96

Development of Smart Poly House for Sustainable Agriculture

Usha Rani Nelakuditi, Kumar Sai Sankar Javvaji and Kowsikesh Kasavajhula

Department of Electronics and Communication
Vignan`s Foundation for Science, Technology and Research, Vadlamudi-522 213, India
E-mail: usharani.nsai@gmail.com

Abstract: The present studies concentrate on the increase of quality agricultural yield with optimal resource utilization against adverse environmental conditions using agriculture 4.0. and deals with the implementation of sustainable green technological solutions known as poly-house farming using sensors, Internet of Things (IoT), cloud and GSM technologies. In this method, farming is performed in a constrained environment created by placing various sensors on the field and monitoring as well as controlling of various field parameters with the help of actuators based on their set thresholds. The parameters considered in this case are temperature, humidity, soil moisture, CO_2 level, light intensity, rainfall condition, water tank level, inside the house. They are all maintained at the desired thresholds by automatically controlling corresponding actuators with the help of IoT. The parameters sensed from these sensors are analyzed using the Thing speak server and recommendations are sent to the end-users through GSM for corrective action through the respective actuator such as fan and motor. Implementation of this work results in the increase of yield with the optimal use of water.

Keywords: Polyhouse, Sensors and actuators, IoT, GSM, Stepper motor, DC motor, DHT11, Moisture sensor, Gas sensor, Android app

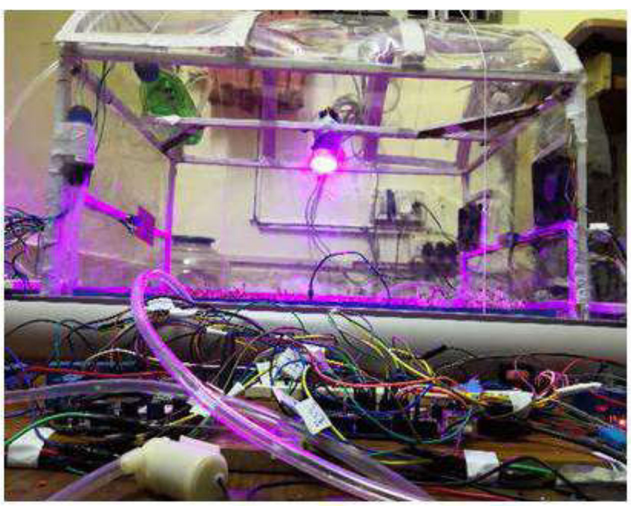
Agriculture is an important sector and has a share of 15.87% in the nation's GDP. The agricultural yield was affected by the population growth, erratic climate changes, and global warming and leads to increased foreign imports. Addressing these issues and earning more profits is possible by the adoption of modern farming techniques such as greenhouse farming. The suitable crops are tomato, cucumber, capsicum, rose, carnation, gerbera, anthurium, strawberry, bell peppers. Polyhouses are primarily constructed to extend growing periods of crops or to increase off-season yields by controlling parameters such as temperature, humidity, Co2, nitrogen, and light intensity. Polyhouses are very beneficial especially for those who prefer organic farming. There are many other advantages such as the yield may be 10-12 times higher than that of outdoor cultivation depending upon the type of greenhouse, type of crop, environmental control facilities, Off-Season cultivation of vegetables/fruits enables the farmer to have a better price realization, Disease-free and genetically superior transplants can be produced continuously, Efficient utilization of chemicals, pesticides to control pest and diseases and water requirement for crops is very limited, hence drip irrigation can be employed in the Polyhouse farming. Though there are many advantages it needs a lot of vigilance and maintenance operations hence in this case more operational expenditure is suspected This work paves the solution for the reduction of operational costs by placing sensors and actuators across the field to gather real-time information periodically from the field, quickly synthesizing the data for control action and also drawing valuable business decisions using IoT and cloud and communicating the same to the end-user (farmer)by using GSM. There are a few solutions available in this area. Prathiba and Sathyanarayana (2015) proposed a Polyhouse using AT89S52 microcontroller, SMS for communication by considering two parameters temperature and humidity only. Jermin et al (2018) proposed and implemented a greenhouse system employed IoT using Node MCU and communication using MQTT protocol. They also considered soil moisture and light intensity sensors in their system. This paper explains the methods of implementation of protected cultivation using Polyhouse or greenhouse cultivation using sensor technology, GSM, cloud, and IoT.

MATERIAL AND METHODS

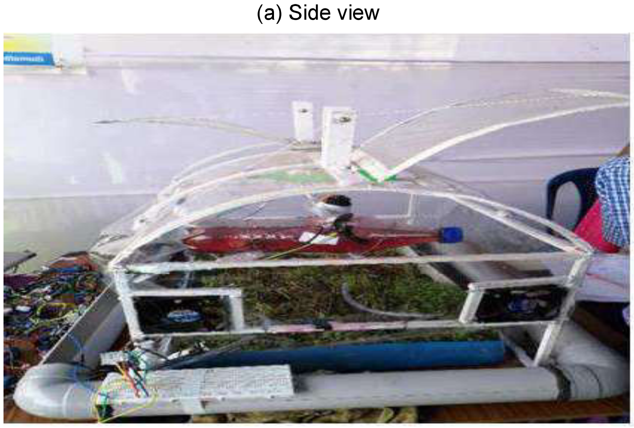
Polyhouse is made of stainless steel rods, covered with a quality polyethylene sheet to protect the crops from solar radiation, diseases and also provides required environmental conditions for the plants was shown in Figure 1(a) and (b), respectively. Drip irrigation was employed for the watering. Parameters such as temperature, humidity, moisture, and CO_2 are sensed using sensors and controlled by using actuators like fans, motors, and ventilators. Functioning and timings of sensors and actuators are controlled with the help of a microcontroller. In this research, operations related to crop, soil, and irrigation management are carried out using sensors, actuators, GSM, SPI protocol, cloud (Thing speak), and IoT. In this way, technology was deployed to a greater extent and playing a big role in the agricultural industry as a result of industry 4.0.

Description: Hardware details of polyhouse are shown Figure 2. The whole system is divided into two parts. Part 1 consists of sensors like DHT11 temperature and humidity sensor, CO2 gas sensor, soil moisture sensor, irrigation tank water level sensor, light intensity sensor, rain detection sensor, heater sprinkler water level sensor and actuators like ventilators, irrigation tank inlet motor, irrigation tank outlet motor, sprinkler tank inlet motor, sprinkler tank outlet motor, heat exhaust fan, light, soak pit, inlet motor are interfaced with Arduino Mega 2560 microcontroller board. Part 2 consists of Arduino Mega 2560, GSM SIM 900A module, ESP8266 Wi-Fi module is also connected to Arduino. Sensor DHT11 is used to sense and monitor temperature and humidity. These sensors are durable, unobtrusive and relatively inexpensive. If the temperature inside the house exceeds the threshold value (25°C) then exhaust fans will automatically switch on by using relay switch. If the humidity exceeds the threshold value (40RHM) then hot water sprinkler will switch on using relay sprinkler.

Hot water tank level sensor is used to detect the water level inside the tank and if the level is below the threshold value then sprinkler water tank inlet will automatically be used to detect the moisture level present in the soil. If the soil moisture level is low (<400) then irrigation tank outlet motor will switch on by using relay and it will be filled. Soil moisture sensor is itch on automatically using relay to water the plants. Irrigation water tank level sensor is used to detect the water level inside the tank if the water level is below the threshold value then automatically water will be filled into the tank by switching on irrigation water tank inlet motor automatically using relay. CO_2 gas sensor is used to detect the CO_2 level inside the Polyhouse, ventilators will automatically open whenever CO_2 level drops below the threshold value, fresh air fills the farm and automatically closes after restoring gas level to normal condition. The ventilators are open with the help of 100RPS gear motors which will drive with the help of



(a) Side view



(b) Top view

Fig. 1. Model of a polyhouse

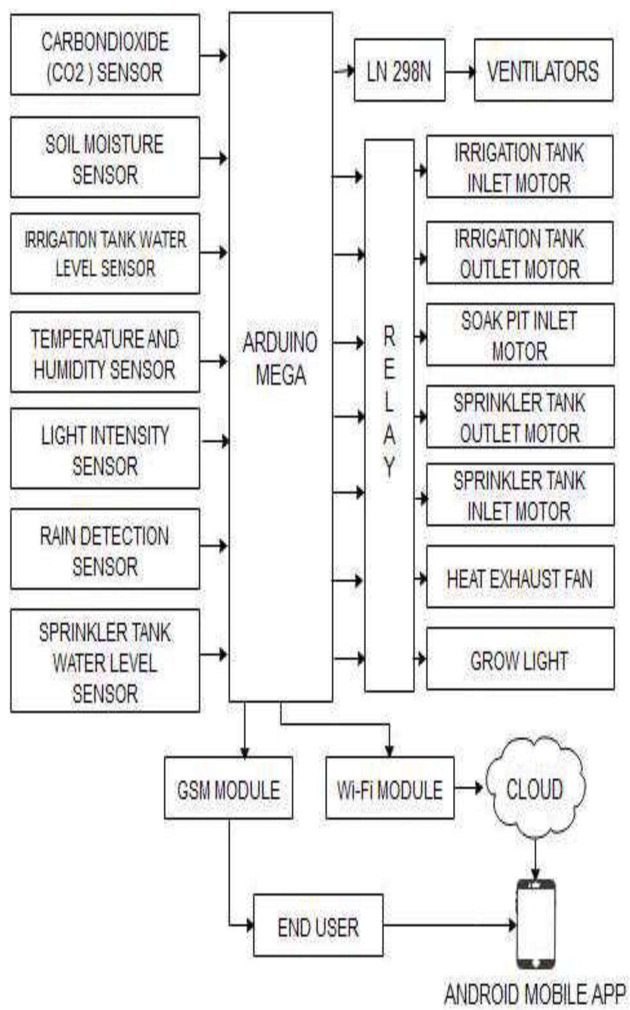


Fig. 2. Block diagram of a polyhouse

LN298N motor driver. Light intensity sensor is used to detect the light intensity inside the polyhouse, if the light level is below the threshold level (50) then the Grow light will switch on automatically using relay. Rain detection sensor is used to detect the rain condition and ventilator will operate based on the existing moisture level of soil. If the soil moisture is less than the threshold value ventilators will open automatically and rain fall directly onto the plants. If the soil moisture is sufficient then the rain water will be collected by automatically switching on the motor with the help of relay and drive into soak pit which is useful to increase ground water level. A relay is an electro-mechanical switch either in ON or OFF position according to the requirement. All sensors send the sensing data to microcontroller then microcontroller will perform action as per the set condition through relay. GSM Sim 900A is used to communicate with the end user (farmer) during emergency. Wi-Fi Module (ESP8266) is used to communicate with the cloud. The communication among these devices is performed using SPI protocol.

Implementation: The primary operation of polyhouse was based on the sequence of steps mentioned in the following algorithm. The exact order of sensors and the corresponding control actions were indicated in the flow chart.

ALGORITHM:

Step 1: Initialization of seven sensors and actuators

Step 2: Collect the data from the sensors time to time and transmit to the controller

Step 3: CPU will process the data and activate /deactivate respective actuators based on conditions drawn by the controller and the sensed data

Step 4: Update the status of sensors / actuators to the cloud

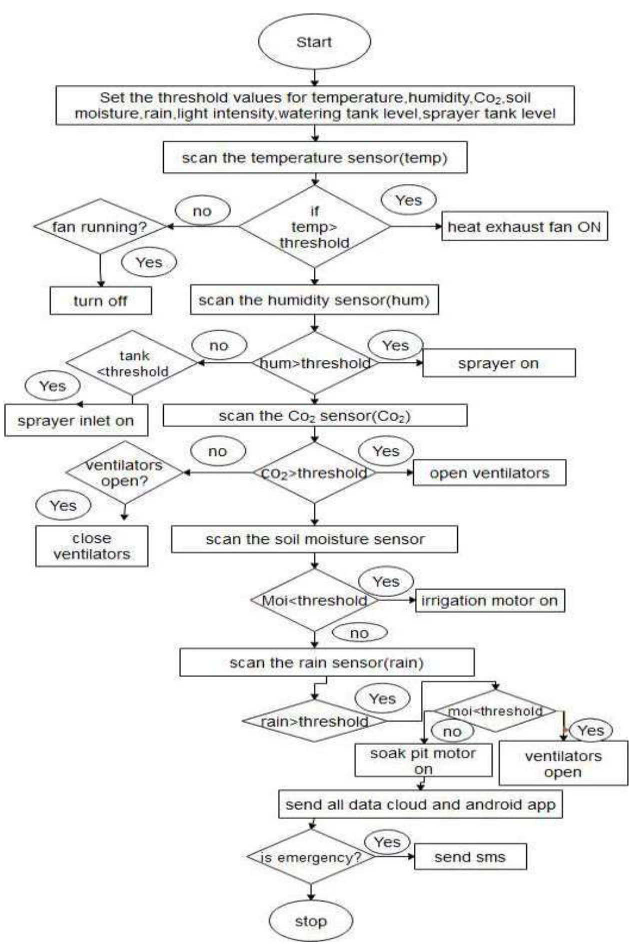
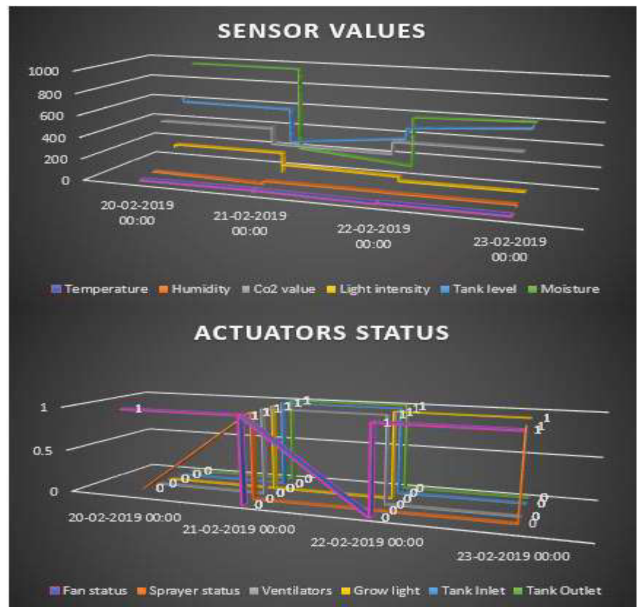
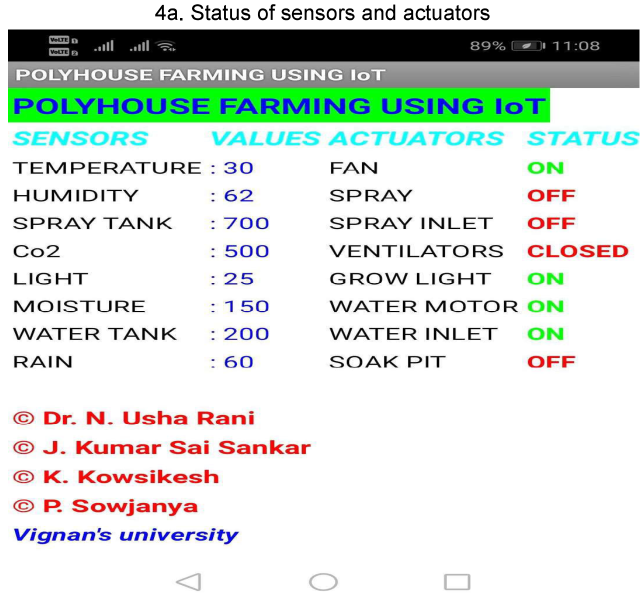


Fig. 3. Flow chart of sequence of operations of sensors and actuators

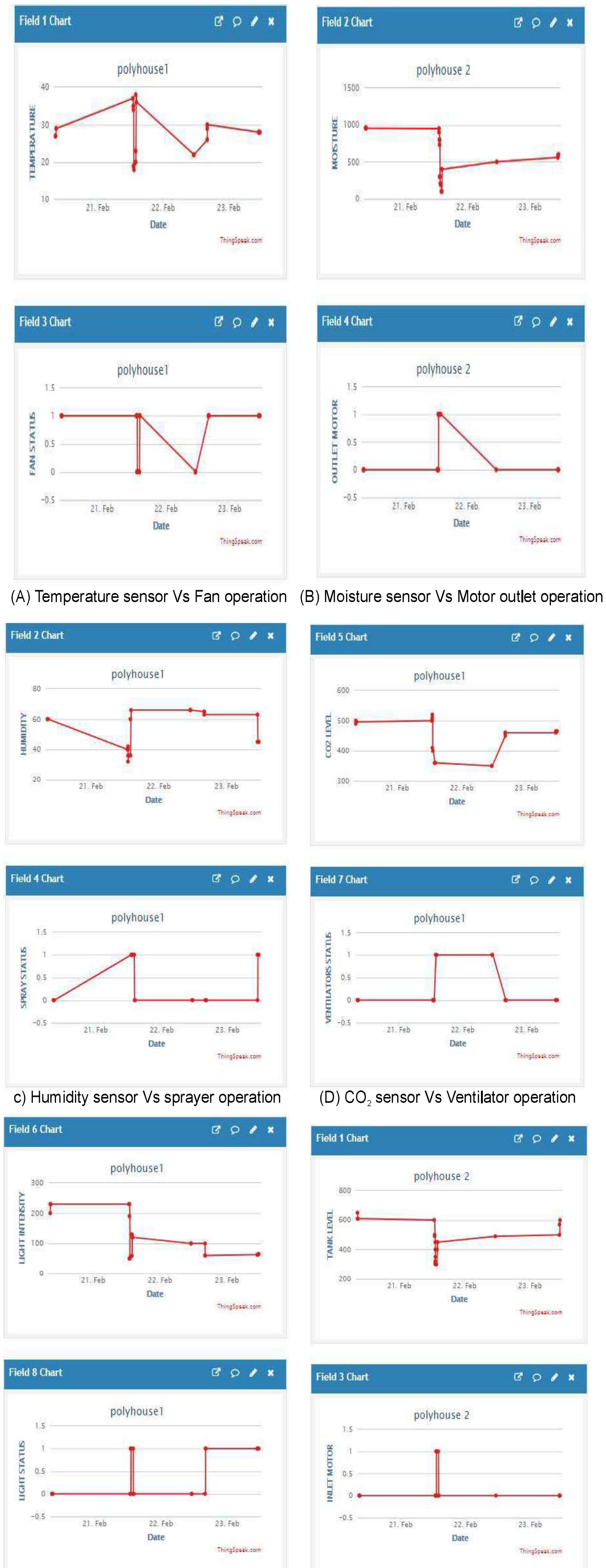


4a. Status of sensors and actuators



4b. Android application

Fig. 4. Operational results of sensors and actuators



(A) Temperature sensor Vs Fan operation (B) Moisture sensor Vs Motor outlet operation

c) Humidity sensor Vs sprayer operation (D) CO_2 sensor Vs Ventilator operation

(E) Light intensity sensor Vs light ON operation (F) Tank level sensor Vs Motor operation

Fig. 5. Thing speak results of sensors and actuators

server (Things peak), and also on Android APP using Wi-Fi.

Step 5: In case of emergency SMS will be sent to the farmer through GSM for the required action.

Step 6: Repeat Step 2 through Step 5.

Flowchart

The first step is to determine the threshold values of measuring parameters of the cultivated crop based on the manuals and real-time data. The existing parameters are measured from time to time and the corresponding actuators are to be enabled as per the requirement. Using rain sensors and soak pit rainwater harvesting also incorporated. The water tank also monitored using a level sensor and filling of the tank is automated through the motor with relays. During emergency end user is enabled through SMS for the required action.

RESULTS AND DISCUSSION

The proposed system was implemented by generating a Code as per the sequence mentioned in the flow chart using Arduino IDE environment and it was ported into the Arduino microcontroller. The code was verified and the results are presented in Figure 4 and 5. In Figure 4(a) indicates Thingspeak results, Figure 4(b) indicating the android app notification to the end user. It was observed that all the sensors are on and off for the set thresholds and actuators also enabled as per the specified action. Same information is emphasized In Figure 5 (a-f) represents the functioning of sensors and actuators.

CONCLUSIONS

Polyhouse was designed and implemented for monitoring temperature, moisture, CO_2, rain detection, light intensity and a water tank level for the crops cultivated in the controlled environment. It was also incorporated automatic open/close of ventilators. Rainwater harvesting is incorporated using soak pit. If the soil moisture is sufficient then the ventilator was closed and rainwater was collected into the soak pit to improve the groundwater level. The yield of mustard seeds cultivated in Polyhouse implemented in this paper was improved 4-8 times higher than the open field. This is because of the maintenance of required parameters during the lifetime. The shelf life of crops also enhanced since they are free from diseases, environmental effects, and continuous monitoring. Though, the initial investment seems to be high, other benefits such as higher crop productivity with the decreased use of pesticides, water, and fertilizer, which in turn keeps food prices down by the reduction of environmental and ecological impact. It is sustainable which can satisfy the food demands of a growing population while conserving and protecting resources and financially viable to growers and consumers. Hence these kinds of commercial setups can support our nation's rising food demand. This system can be further improved by measuring a few more parameters that affect yield such as pH and nitrogen which are important micro-nutrients in the soil for proper plant growth present in the soil. By adding crop rotation schemes soil fertility can be restored. By using efficient WAN system mplexity can be reduced.

Received 28 March, 2020; Accepted 30 June, 2020

REFERENCES

Jermin TC, Sarasvathi V, Harsha MS, Bhavani BM and Kavyashree T 2018. An Automated greenhouse System using agricultural Internet of things for better crop yield. *Smart Cities Symposium 22-23 April 2018, Bahrain*: 6-8.

Prathiba Jonnala and Sathyanarayana GSR 2015. Wireless sensor network for polyhouse cultivation using ZigBee technology. *ARPN Journal of Engineering and Applied Sciences* **10**(10): 22-31.