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# IoT Based Greenhouse Climate Monitoring and Controlling System

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***Abstract:*** This paper presents the concept of climate monitoring and controlling of the agricultural greenhouse system. The greenhouse system (GHS) provides a favorable environment for the crops. The GHS is a class of nonlinear and complex systems. In the GHS main task is to monitor and control the inside temperature and inside humidity. Internet of Things is one of the modern advanced Technologies, providing total connectivity and management of sensors, devices, users with information. In our system, continuous monitoring and controlling of inside temperature and inside humidity can be achieved with IoT based platform and also provide notification with android based applications to farmers to take corrective actions such as ventilation and fog to the system . The database of inside temperature and inside humidity are stored in CSV file, and the results are displayed in a webpage as well as in the android based application, from where the user can outlook them directly.

***IndexTerms*** **- Greenhouse system, Internet of Things, Node MCU , DHT 11 Sensor, Raspberry Pi**

## I. SYSTEM INTRODUCTION

A greenhouse can be defined as a closed construction which is used to protect the crops from external environment [1]. It offers a supportable and efficient development of the plants throughout the year. To achieve environmental conditions, several control algorithms, mathematical models (nonlinear/linear), and stability analysis were proposed to control the GHS climate parameters as per requirement under load variations and uncertain parameters[2]. The main benefits of GHS is as follows : Artificial Climate Control ,Higher production rate, Higher value and higher quality crops can be grown, Drastic reduction in wastage of Fertilizers and Pesticides, Efficient use of Irrigation Water, Nursery for all vegetable crops can be grown ,Crop Health Detection [3]. The crop experiences internal environment condition such as inside humidity, inside temperature, and $co_2$ concentration. The external environment disturbances such as outside air temperature, outside air humidity, wind velocity, and solar radiation[4]. The main parameters that can be monitored and controlled are inside temperature ($T_{in}$), inside humidity ($H_{in}$), and inside $co_2$ concentration level. Greenhouse farming is a method that enhances the yield of crops, vegetables, fruits etc. Greenhouses control climate parameters in two ways; either through manual control or a automatic control mechanism. However, since manual intervention has disadvantages such as production loss, energy loss, and labor cost, these methods are less effective [5]. A smart greenhouse through IoT embedded systems not only monitors intelligently but also controls the climate. Thereby removing any need for human intervention. Basic dynamics affecting crop growth are solar radiation, water content in soil, temperature, humidity etc. Numerous researchers have worked with water sprinkling and irrigation system. They opted for different methods for determining the soil moisture condition[6].

An article on the automated water supply system for urban residential areas showed that their system can be used to effectively manage water resource[7]. In the conservative method of cultivation, some problems occur like constantly changing weather conditions which affect the crop, and a crop can be affected by the disease. So, the agriculture method should be updated to give a maximum quantity of the crop production and the dependency on the crops should move towards a supportable agriculture system with the help of technology as adopted by various nations [8]. Dynamics of greenhouse system are varying continuously so to achieve climate conditions several mathematical models (Nonlinear/Linear), control algorithms were proposed to control the GHS climate parameters as per given conditions under the effect of disturbances and parameter uncertainties [9]. A mathematical model of GHS obtained by the energy and mass balance principle. it has been observed from many kinds of literature that the GHS is a complex dynamic system so the mathematical model of this system achieved by object-oriented language dymola[10]. Several simulation, a virtual lab, and interactive tools have been developed for the diagnostics of GHS characteristics[11]. In this system we have implemented soil moisture sensors, temperature & humidity sensors, Raspberry PI and water Sprinkler system. Moisture sensors are installed near the roots and temperature & humidity (DHT11) sensor is installed further away to detect the temperature and humidity. These sensors continuously sending the data to the Raspberry PI to analyze the results. The Raspberry PI takes the control action based on the setpoint given to it. Will turn on fog system, whenever it required. Android based

application gives notification of weather data to farmers and also stored the data in csv file. The final collected environmental data sent to smartphones via online mode to the farmers to make the proper overlook on their fields.

## II. SYSTEM IMPLEMENTATION

Greenhouse climate control system provides favourable environment to the crop. Different sensors that measure the environmental parameters according to the plant requirement are used for controlling the climate in a smart greenhouse [12]. Then, a IoT based system creates for remotely accessing the system when it connects using IoT [13]. The Different sensors that are used to measure the environmental parameters to the plant requirement for controlling the environment in smart greenhouse is as follows: Soil Moisture Sensor**:** The two copper leads act as the sensor probes. They are immersed into the specimen soil whose moisture content is under test. The conductivity of soil depends upon the amount of moisture present in it. It increases with increase in the water content of the soil that forms a conductive path between two sensor probes leading to a close path to allow current flowing through. Light Sensor: The light sensor is extremely sensitive in visible light range. With the light sensor attached to the system when the surrounding natural lights are low, it displays the digital values corresponding to the light intensity. Temperature and Humidity Sensor is used for temperature and relative humidity. The change in Temperature and relative humidity of the surroundings would result in display of values[14].

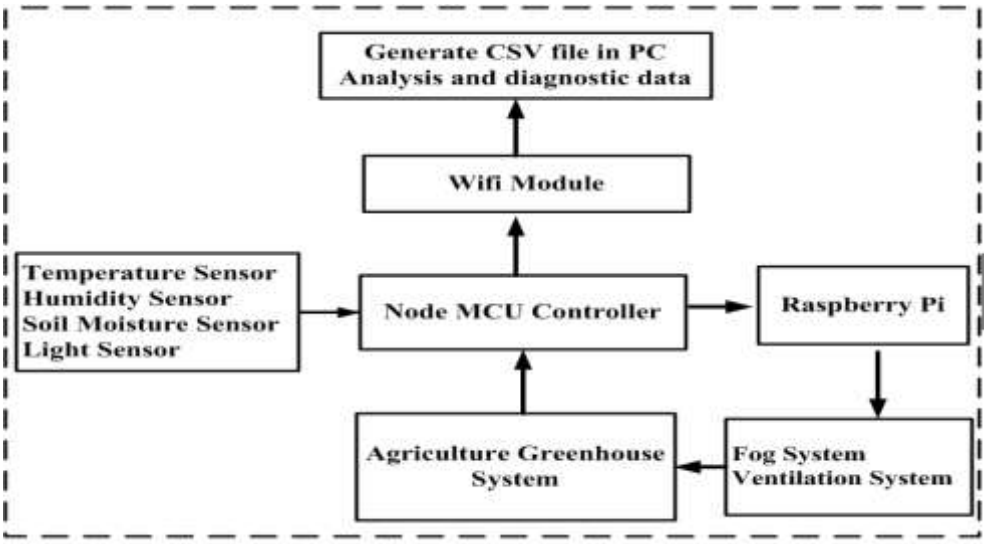


**Figure 1:** Schematic Diagram of IoT Based Climate monitoring and controlling system of GHS

The block diagram of greenhouse system is as shown in above figure 1. The Node MCU controller is used to obtain values of physical data through sensors connected to it. And then data collected by the sensors are given to the pc in csv file. IOT based Greenhouse Environment Monitoring and controlling system use four sensors to detect the Temperature, Light, Humidity and Soil moisture in the agriculture greenhouse.

Temperature Sensor is used to detect the temperature inside the greenhouse. Reading from the sensor is sent to the microcontroller. CSV file generated using this system provides the database of all the values with time stamp. A CSV file is a commonly used file extension when it comes to spreadsheets. Even software programs that don't look and feel like a spreadsheet application will frequently offer a CSV as an output file for downloading a data set, such as a report of results, actions, or contacts. The raspberry Pi and node MCU is connected to different relays. One of the relays is connected to a fog system. If the temperature is above or below the threshold value, the raspberry Pi controller would send signals to turn ON the ventilation system or fog system depending on the conditions. The Raspberry Pi is a low cost, compact size computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of doing everything you'd expect a desktop computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games. NodeMCU is an open-source based firmware developed for the ESP8266 wifi chip. By exploring functionality with the ESP8266 chip, NodeMCU firmware comes with the ESP8266 Development board/kit i.e. NodeMCU Development board. Light Sensor is used to detect the amount of sunlight inside the greenhouse. Reading from the sensor is sent to the microcontroller. Similarly, the Humidity sensor is used to detect the humidity value and the Soil moisture sensor (two probes dug in the soil) is used to identify the soil moisture. If the humidity value sensed by the sensor is above the setpoint value OR if the soil moisture reduces, the microcontroller would turn on the ventilation system to decrease the humidity and will open the fog system to increase the moisture in the soil. At the same time, data regarding these parameters are sent to the IOT module (ESP8266). The data sent to the IOT is sent at regular intervals irrespective of any threshold mismatch found. ESP8266 is a chip used for connecting micro-controllers to the Wi-Fi network and make TCP/IP connections and send data. Data, which is sensed by these sensors, is then sent to the IOT. The Pre-requisite for this project is that the Wi-Fi module should be connected to a Wi-Fi zone or a hotspot.

## III. RESULTS AND DISCUSSION

The experimental hardware setup of greenhouse system is as shown in figure 2. The node MCU is used to obtain values of physical data through sensors connected to it. And then data collected by the sensors are given to the pc in csv file for database with timestamp. The IoT based system shown in figure 2 automatically and continuously measures the temperature and moisture level in the GHS using a monitoring unit that comprises of several sensors. The fog system and ventilation system is also fitted with a control unit. When the moisture level drops below a certain threshold, the system sends a wireless message to the fog system . Once these valves receive the message, the power supply to the fog system and valves are altered to activate the pump and open the valves, causing water sprinkler flow through the system and water the soil in that particular region. When the moisture level rises above a certain level, the system sends a wireless message to the fog system and the pipeline valves in the irrigation system, altering the power supply to the water pump and valves to close them, causing water to stop flowing through the system and the pump to stop allowing water from the water source flow into the irrigation pipelines and into the soil in that particular region. The automated irrigation system can be applied to a single land section requiring irrigation or multiple land sections with differing irrigation requirements. While the system is to be used primarily for land irrigation, it can also be used for automated watering of livestock, and for cooling of plants and livestock. A simple schematic of the automated irrigation system for surface irrigation of a single land section is shown in Figure 1.

**Figure 2:** Hardware setup of IoT Based Climate monitoring and controlling system of GHS

**Figure 3:** Sensors for the GHS

Figure 3 Shows that the DHT 11 sensor is placed to the GHS for the measurement of the inside temperature and inside humidity. The YL69 is an inexpensive soil moisture sensor used to detect the amount of moisture content present in the soil. The operating voltage is 3.3v to 5v and current is 35mA.This sensor consists of two electrodes which when comes in contactwith the soil the voltage fluctuates i.e. the output voltage decreases when the moisture is present and the output voltage. DHT11 is one of the basic affordable digital sensors which can measure temperature and humidity. It has an operating voltage of 3 to 5 volts & max-current

of 2.5mA.The temperature range lies between 0°C to 50°C, while the humidity percentage ranges between 20% to 80%. Itconsists of a thermistor which employs Negative Temperature Coefficient (NTC) and a humidity sensing component to detect the moisture in the air. Increases when the soil is dry.

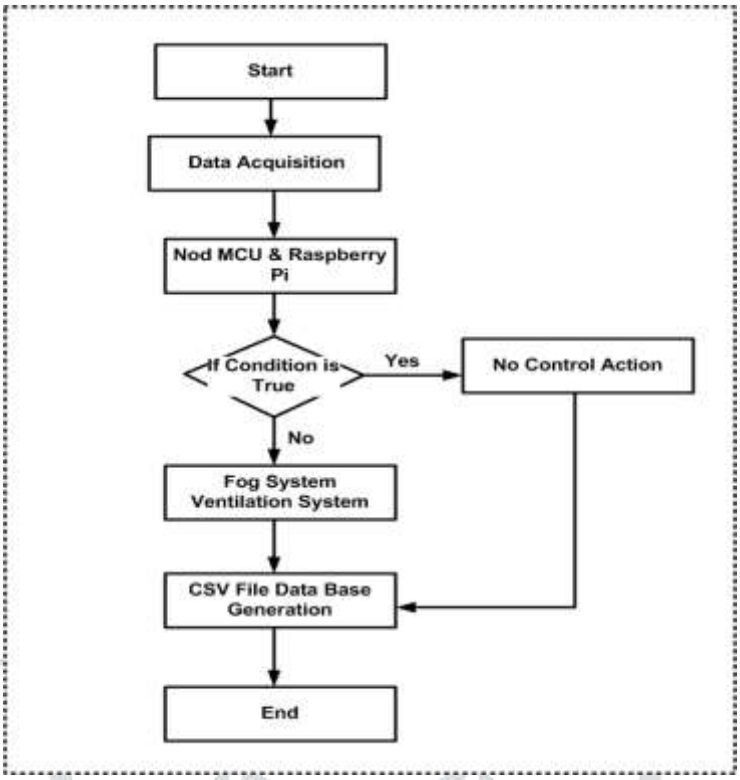


**Figure 4:** Flow chat of the system

Figure 4 shows the flow chart of the entire system. This system first senses the required parameters such as temperature, humidity and soil moisture. Next step is to compare the data with the setpoint given by user. Finally if the error generates controller takes the corrective action based on the given control action.

## IV. CONCLUSION

In this proposed work, low-cost IoT-based climate monitoring and the controlling system has been developed. In this system, GHS parameters such as inside temperature, inside humidity, and soil moisture are monitored using IoT based data acquisition system. Based on the setpoint if any parameters exceed the reference value corrective action is taken. All the GHS parameters data are stored in a CSV file on a PC. The android-based interface is also given in the system for monitoring and controlling purposes. So by implementing the IoT-based monitoring and controlling system greenhouse climate can be controlled and achieve the desired yield for the crop.

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