Dynamic modeling of a Green House using Arduino

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Abstract--- *The world's population depends mainly upon agriculture. But the agricultural lands are being affected due to the extension of urban society into rural areas. Hence, the yield of crop has been decreasing year by year. Farmers have to bear huge financial loss because of wrong prediction of weather. In this context, the sensor technology is used for automatic detection of the abnormal environmental parameters inside the greenhouse. The growth of crop in greenhouse depends on wind, temperature, humidity and other parameters. Accurate measurement is important and adjusts these parameters according to the weather. This paper focuses on the development in the agricultural sector with minimum water usage and the utilization of the solar energy. These parameters are measured with the help of sensors. These measured parameters are given as input to the microcontroller which was programmed with reference values of a particular crop and are compared. The output of the microcontroller is given to the hardware unit for their further functioning according to the environment. To give more importance to conservation of energy, solar energy is used. The solar panel with sun tracker is also designed to increase the efficiency. A greenhouse environment parameters monitoring system based on wireless communication technology. The outputs of the sensors were given to Arduino UNO microcontroller. The output of the Arduino was given to the control unit. The control unit changes the adjustments in green house.*

Keywords: *Sensor, Temperature, Wind speed*

I. INTRODUCTION

Demand for food product increases extremely due to drastic population growth. Indoor horticulture farming, which is cultivation of plants inside a building with glass walls and root under controlled condition, provides a solution to meet the demand and to achieve constant yield throughout the year. This type of farming in indoor place is called as Greenhouse cultivation [1]. Irrigation by help of fresh water resources in agricultural areas has a crucial importance. Because of highly increasing demand for fresh water, optimal utilization of water resources [2] has been provided with greater quantity by using automation era and its equipment consisting of solar power, trickle irrigation, sensors and remote command.

An automated irrigation system was prepared to optimize water use of farming crops. The organization delivers a distributed wireless network of ground moisture and temperature sensors located in the base zone of the plants. In summation, a gateway unit handles sensor information, triggers actuators, and sends data to a web utility. A set of rules was advanced with threshold values of temperature and soil moisture [3] that was programmed into a microcontroller based gateway to hold in water quantity.

II. IRRIGATION SYSTEM

To make the irrigation simpler, an automated controller is developed to monitor several environmental parameters. This project work utilizes conventional source of energy as a part of conservation of energy. Several sensors were introduced like rain sensor, temperature sensor, soil moisture sensor and anemometer. Temperature [4] and soil water content are the most important parameters in irrigation system. Each sensor having its own importance in cultivation. For proper cultivation of crops, proper check on soil moisture has to be monitored continuously. Rain sensor could be done by simple PCB using etching process can be used as a rain sensor. Too much temperature can fade away the crops. In order to avoid temperature sensor was introduced. Now along with rain, temperature, and soil moisture, wind is also an important parameter. Anemometer is used to measure the wind speed. A control unit is developed in the irrigation system depending on the sensors output. Depending on the sensors used, different control measures were installed. The different control units are valve, shield, exhaust fan and window. A valve is placed across the field, which help in drip irrigation. The valve is supposed to be opened or closed depending on the soil moisture level. Shield can act as a cover to the field. The shield gets activated depending on the output of rain sensor. The shield rolls the sheets when there is rain and wraps the sheet when there is no rain. The exhaust was provided to prevent the crop from getting faded out due to high temperature. The exhaust fan will be made on as the temperature exceeds a critical temperature. A window is placed across the field. An arduino [5] module is used as an interfacing between the sensors and the environment. To reduce the resources solar energy [6] is used for working of sensors. The Figure 1 represents the bock diagram of automated green house.

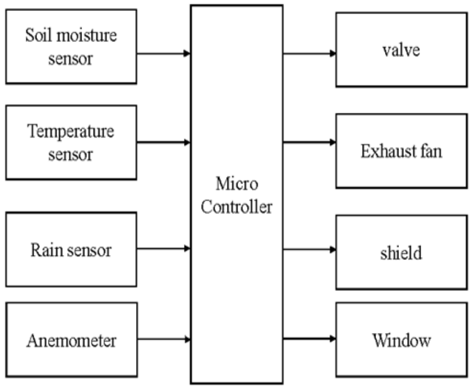

Figure 1: Block Diagram of hardware model

III. OPERATION

The automated green house block diagram is shown in Figure 1. The methodology is executed in three steps. They are Sensing, Data acquisition and Decision making & Control unit. Each sensor and its interfacing are discussed in the next sections

A. Soil Moisture and Interfacing

The next stage of consideration was moderately wet state. This is the state of requirement for agriculture. A threshold value was kept at this value measured voltage value. The microcontroller checks this voltage and control the irrigation. If the voltage was below a threshold value, i.e., the gypsum block was very dry, the microcontroller activate the motor [7] and drip irrigation occurs. Soil moisture sensor was placed across the field to check the moisture level. The moisture level was classified into 3 levels: low, medium, high. According to the above moisture level, the valve was opened. When the moisture level is low, the valve was opened for 5sec and it again checked the moisture level. This was a continuous process till the moisture was increased to medium. When the moisture level was medium, the valve was opened for 3sec and it again checked the moisture level. This process was a continuous one, till the moisture level was high. When the moisture level was high, the valve was closed. This process with LCD display is represented in Table 1. The valve used for the water to flow is shown in Figure 3.

Table 1: Condition for Working of a valve

LCD Display	Valve
Moisture Level: LOW	Open for 5 Sec
Moisture Level: MEDIUM	Open for 3 Sec
Moisture Level: HIGH	Closed

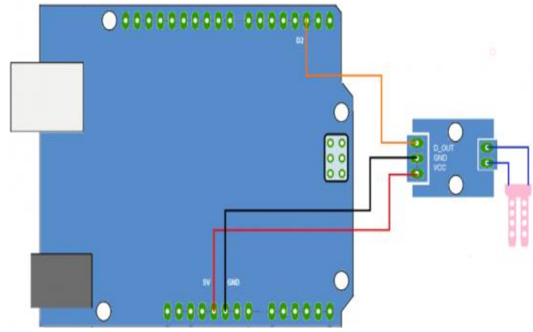

Figure 2: Circuit diagram of soil moisture-valve circuit

The hardware module as shown in Figure 2 consists of an Arduino microcontroller and a pre-wired soil moisture sensor module as shown in Figure 4. The soil moisture sensor module, built around the LM393 comparator. This digital output (wet soil → L / dry soil → H) is routed to one I/O terminal (D2) of the Arduino microcontroller. Based on this input (at D2) Arduino gives an active-high (H) output through D13 when soil is dry, and an active-low (L) output when soil is wet. This is given in Table 2.

Figure 3: Valve controller

Table 2: Output of a soil moisture sensor

Soil Condition	D13 Output & D13 Led Status
Wet	Low(L)/ OFF
Dry	High(H)/ON

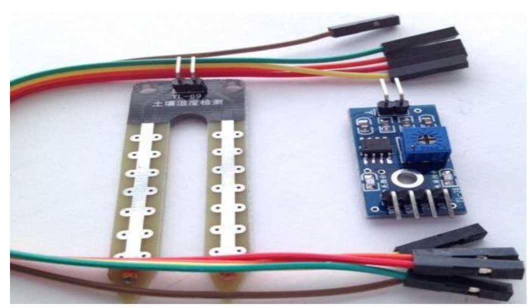

Figure 4: Soil Moisture Sensor Module

The +5V supply line (VCC) and Ground of the module is linked to the 5V line and common (0V) of the Arduino. The digital signal output to be detected (usually marked as DO in the module) is applied to D2 input of the Arduino. Analog output (marked as AO) from the module is not used here. Sensor-head of the module contains two probes in a small metal PCB. When the sensor-head is inserted in wet soil, moisture bridges the probes through a low-resistance path (when soil is dry, resistance between the probes is also high). A potentiometer is included in the module for adjusting the soil wet/dry detection sensitivity according to actual requirements.

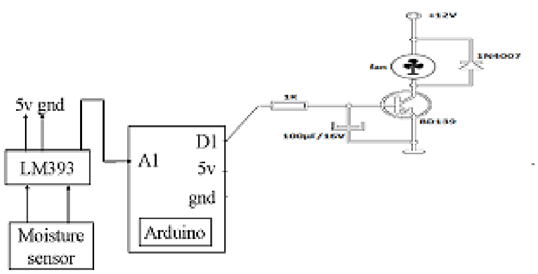

Figure 5: Interfacing of a Soil Moisture Sensor

The interfacing diagram of the soil moisture sensor is shown in Figure 5. If higher current loads are to be driven a PNP transistor can be added to the module's digital output. Here, the addition of transistor controls an electromagnetic relay for driving high-current/high voltage loads like water pump motors through its N/C contacts (when soil is wet, relay remains in energized state).

B. Temperature Sensor and Interfacing

LM35 is an analog temperature sensor used in this module. Microcontrollers do not accept analog signals as their input directly. So, an ADC (Analog to Digital Converter) is required to convert analog to digital. Arduino and most modern day micro controllers come with inbuilt ADC. Arduino UNO has an in built 10 bit ADC (6 channel). This ADC of Arduino is used to convert the analog output of LM35 to digital output. For interfacing analog output of LM35 is connected to A11analog input pin of Ardiuno. The interfacing with Arduino is given in the Figure 6.

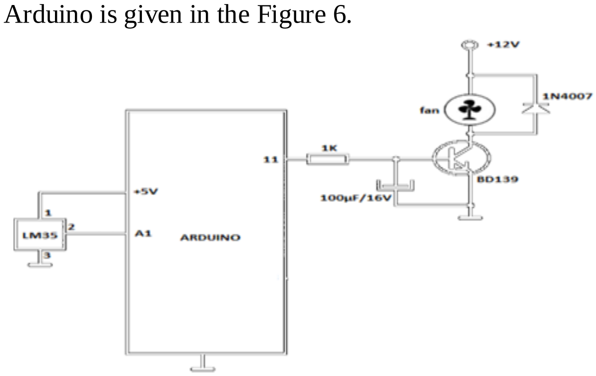

Figure 6: Interfacing of Temperature Sensor

Connection of LM35 to Arduino UNO is shown in Figure 6. The +5V supply line (VCC) and Ground of LM35module is linked to the 5V line and common (0V) of the Arduino. Connect Vout (the analog out of LM35) to A1 of Arduino.

C. Rain Sensor and Interfacing

The rain sensor module is an easy tool for rain detection. It can be used as a switch when raindrop falls through the raining board and also for measuring rainfall intensity. The module features, a rain board and the control board they are separated for more convenience, power indicator LED and an adjustable sensitivity through a potentiometer. The analog output is used for detection of drops in the amount of rainfall. LED will be turned ON by connecting 5V power supply. When rain board has no rain drop, D_0 output is high and when dropping a small amount water, D_0 output is low, the switch indicator will turn on. To restore the initial state, brush off the water droplets which makes output is at high level. The working of the rain sensor was checked using the multimeter. The buzzer of the multimeter was activated when water was dropped on the PCB. When rain falls on the PCB, the Vcc and the ground of the circuit gets closed. When the circuit gets closed, the shield was activated using the motor via microcontroller. Interfacing with the Aurdino is given in Figure 7.

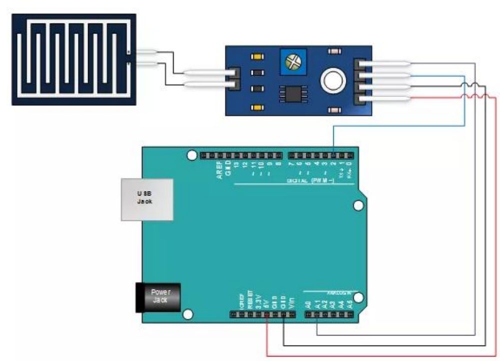

Figure 7: Interfacing of rain sensor-shield

D. Shield and Interfacing

A shield was made to provide cover the field. The shield can prevent the field from damage caused by the rain. The shield was designed using rack and pinion method. The two motors were used to roll the sheet and wrap the sheet. A single driver was used to roll and wrap the sheet. Plywood was placed to provide mechanical support to the shield. The plywood was drilled properly and the scrap of the printer was placed on the top. The motors were placed across the board. This arrangement is shown in Figure 8. The microcontroller (Arduino) was used to activate the roller. When rain falls on the rain sensor, it gets shorted and since it was connected to the microcontroller, the microcontroller becomes activated. The microcontroller enables the motor and help to roll and wrap the sheet. When rain falls on the rain sensor, the shield was activated by the microcontroller such that the shield rolls the sheet. As the raining stops, the shield rolls the sheet back into its initial state. Both the motors activate the same driver. Thus reduces the wastage of the space.

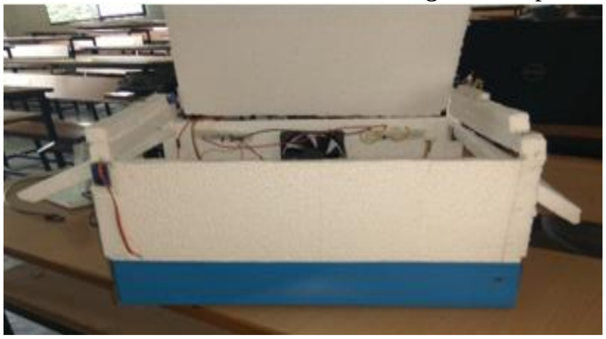

Figure 8: Rain Cover Shield

E. Wind Speed Detection

Wind is an important parameter in agriculture. Too much wind can damage to the crop, as strong wind can uproot the crops. Anemometer was used to measure the wind speed. Anemometer consists of rod and cups. They are wield to form the anemometer as shown in Figure 9.

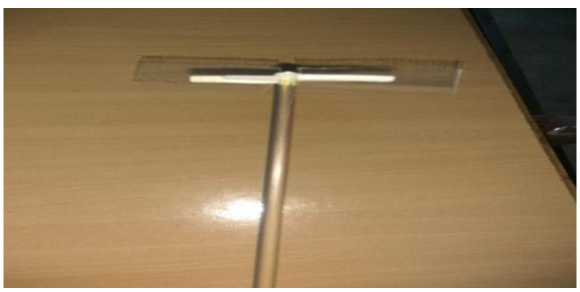

Figure 9: Anemometer

An IR module along with the anemometer was used to measure the wind speed. An IR module consists of a comparator, variable pot and two LED's. One of the LED is the IR transmitter while the other one is the IR receiver as shown in Figure 10. When IR rays react back to the IR module, a pulse is formed at the output.

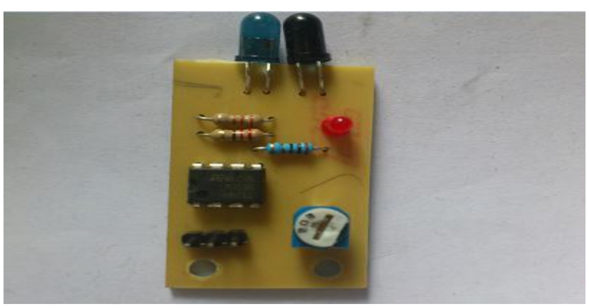

Figure 10: IR Module

As the leaf of the anemometer cuts the IR rays, these rays were reflected back to the IR module and pulse was formed at the output. The distance between the IR module and the obstacle can be varied by adjusting the variable pot. The variable should not be changed again, as it cannot provide correct output. The number of pulse formed at the IR module is used to measure the wind speed in rpm. The output of the IR module was send to the microcontroller. The microcontroller activates the window. The position of the window frame was varied depending upon the wind speed. When the wind speed was slow, the frame of the window was perpendicular with respect to the field, so that maximum wind can enter the field. When the speed of the wind exceeds a predetermined value, the window was readjusted. The entire green house implementation is shown in Figure 11.

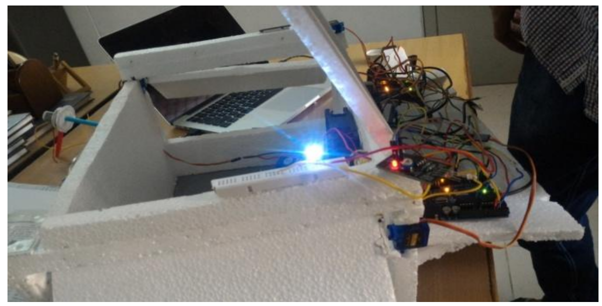

Figure 11: Implementation of green house

IV. RESULTS

All required sensors are assembled and their respective working is observed. The outputs of the rain sensor, moisture sensor, temperature sensor and anemometer were sent to the Arduino, which is already programmed with the reference values. Based on the threshold detection, decision is made to operate the control unit. Rainfall sensor used to close the top shield. Fan is operated when temperature is high. Water driver is used to pump the water to field when low moisture is observed. Side shutters are closed when high wind speed is present. For utilization of solar energy, solar tracker is used.

Figure 12a indicates the user interface window of Aarduino which reads the temperature from the temperature sensor. If the temperature is less than threshold level of 42^0 C, then the cooling fan is in OFF conditions in the green house shown in Figure 12b.

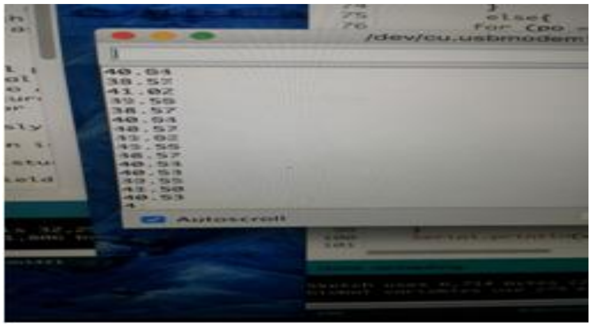

Figure 12a: Temperature sensor output values below threshold level of 420C

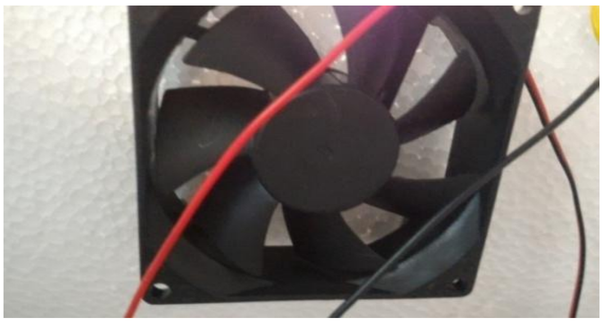

Figure 12b: Temperature sensor output values below threshold level of 420C, cooling fan is in OFF condition

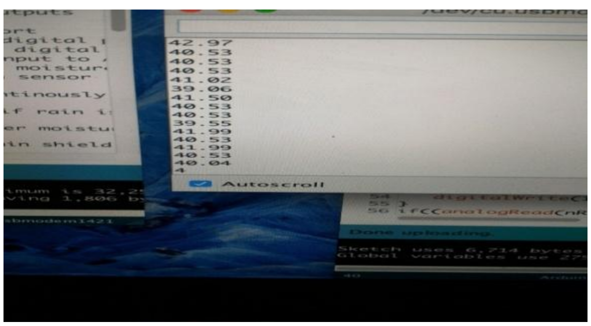

Figure 13a: Temperature sensor output values above threshold level of 420C

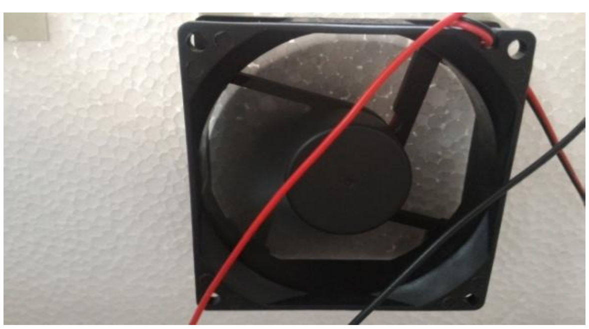

Figure 13b: Temperature sensor output values above threshold level of 420C, cooling fan is in ON condition

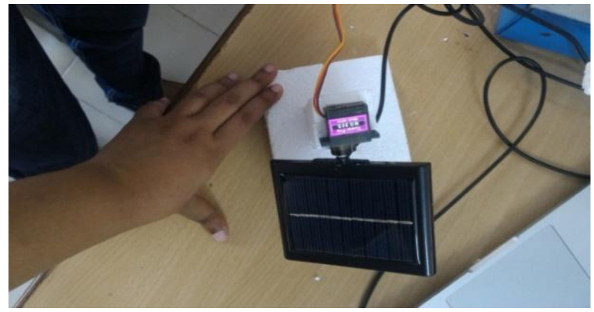

Figure 14a: Tracking solar panel in the sun direction (EAST)

Figure 13a and 13b indicates that if the temperature is greater than threshold level of 42^0 C, then the cooling fan is in ON conditions in the green house.
Figure 14a and 14b represents the photographs of solar panel tracking the sun direction and rotates accordingly. This solar panel is controlled by a stepper motor.

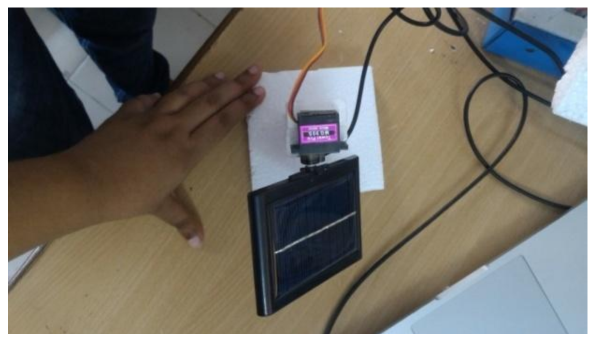

Figure 14b: Tracking solar panel in the sun direction(WEST)

A rain sensor is used in the green house to check the rainy condition. If it is rainy, initially the rain sensor gives the command to the arduino to check the moisture content in the soil. To measure the moisture content in the soil, a moisture sensor is dipped in the soil and measure the voltage level read by the moisture sensor. When the moisture level is low, the valve was opened for 5Sec. This was a continuous process till the moisture was increased to medium. When the moisture level was medium, the valve was opened for 3Sec. This process was a continuous one, till the moisture level was high. When the moisture level was high, the valve was closed. The entire process is shown in the Figures 15a, 15b and 15c.

Figure 15a: Rain sensor with soil moisture sensor

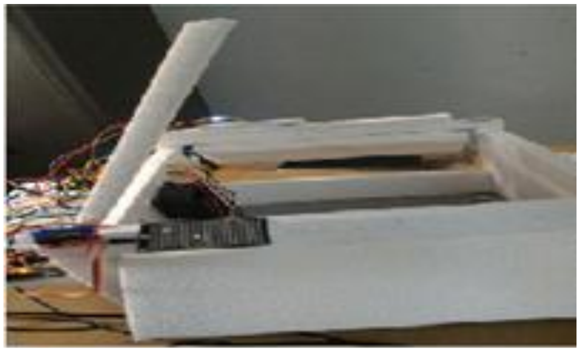

Figure 15b: Rain shield is opened as moisture in the soil is not sufficient.

Figure 15c: Rain shield is closed as moisture in the soil is sufficient

When the wind speed was slow, the frame of the window was perpendicular with respect to the field, so that maximum wind can enter the field. When the speed of the wind exceeds a predetermined value, the window was readjusted. This is given in the Figures 16a and 16b.

Figure 16a: Wind speed is slow and side windows are open

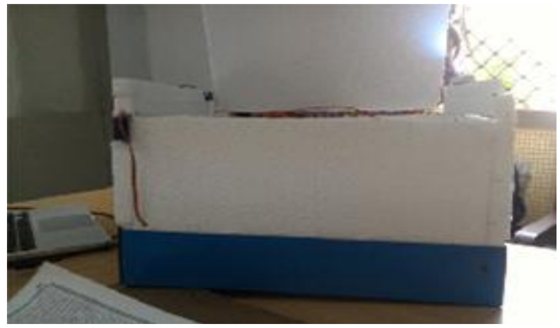

Figure 16b: Wind speed is high and side windows are closed

V. CONCLUSIONS

Automation of a Green House is a very helpful idea in the modernized way of growing crops. Here, most of the environmental parameters such as wind, soil moisture, rain were successfully monitored and were handled in such a way that they don't affect the cultivation adversely. By this method, we could efficiently utilize the resources so that no wastage occurs. In the case of soil moisture sensors, excess watering and scarcity of water in the soil can be easily monitored and can be controlled. The variability of soil type across one's property will affect the number of units required. If we are placing the soil moisture sensors at different levels, then the growth of the root of the plant can be monitored by constantly monitoring the moisture content in different levels. In the case of rain sensors, as the shield is provided, rain water harvesting technique could be effectively utilized as the conserved water could be utilized for irrigation methods in the later stages. Calibrated the temperature of the surroundings and will be compared with the reference value of the crop temperature. If temperature is more than required then fan gets operated automatically.

REFERENCES

[1] Xiaoyan, Z. Xiangyang, D. Chen, C. Zhaohui, S. Shangming, and Z. Zhaohui, “The design and implementation of the greenhouse monitoring system based on gsm and rf technologies,” in International Conference on Computational Problem-solving (ICCP), 2013, Oct 2013, pp. 32–35.

[2] K. A. Czyzyk, S. T. Bement, W. F. Dawson, and K. Mehta, “Quantifying water savings with greenhouse farming,” in Global Humanitarian Technology Conference (GHTC), IEEE, Oct 2014, pp. 325–332.

[3] A. Bseiso, [3] B. Abele, S. Ferguson, P. Lusch, and K. Mehta, “A decision support tool for greenhouse farmers in low-resource settings,” Global Humanitarian Technology Conference (GHTC), IEEE, Oct 2015, pp. 292–297.

[4] P. Laiolo, S. Gabellani, L. Pulvirenti, G. Boni, R. Rudari, F. Delogu, F. Silvestro, L. Campo, F. Fascetti, N. Pierdicca, R. Crapolicchio, S. Hasenauer, and S. Puca, “Validation of remote sensing soil moisture products with a distributed continuous hydrological model,” in Geoscience and Remote Sensing Symposium, July 2014, pp. 3319– 3322.

[5] Y. A. Badamasi, “The working principle of an arduino,” in 11th International Conference on Electronics, Computer and Computation (ICECCO), Sept 2014, pp. 1–4.

[6] M. Mahdavian, M. B. Poudeh, and N. Wattanapongsakorn, "Greenhouse lighting optimization for tomato cultivation considering realtime pricing (rtp) of electricity in the smart grid," in 10th International Conference on Electrical Engineering/ Electronics, Computer, Telecommunications and Information Technology (ECTI-CON), 2013, May 2013, pp.1–6.

[7] Mandeep Sing, Rekha, Balwinder Singh, "Microcontroller Based Clockwise/Anticlockwise Stepper Motor Controller Using PC Keyboard Via Com Port", International Journal of Computer Science & Communication, Vol. 1, No. 1, January-June 2010, pp. 189-191.