Smart Urban Rooftop Greenhouse with WSN Based Precision Technology

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***Abstract*—With more and more urbanization, more educated population is exploring farming in a smart way with maximized production and quality yields by deploying modern technologies. The advanced technology trends permit this in efficient ways and cost-effective way. Deployment of technologies to understand, monitor and control the needs of the crop is the key to the smart farming which is termed as greenhouse farming or urban farming [1]. The combination of sensor, signal processing, control, communication and networking technologies are back bones of new smart farming. With these it is possible to monitor both the physical and environmental parameters, learn the optimized set of them needed for the particular flower/vegetable/crop and control them for better yield. This Paper discusses WSN based mix of technologies as adopted to greenhouse farming for growing bell pepper/capsicum by monitoring and controlling temperature, humidity, soil moisture and light parameters. With this solution, it was possible to achieve 3-4 times higher yield in bell pepper/capsicum than that of outdoor cultivation in a short-term cycle. Novelty of this system also lies in learning the right requirements for the crop and better utilization of the same for future cycles of farming.**

***Index Terms*—urban farming, rooftop farming, greenhouse, WSN, ZigBee**

I. INTRODUCTION

According to the *2011 census, o*ver 50 % of the world population live in urban cities, by 2030, the number will rise to 70 %. With more and more urbanization, more educated population is exploring farming in a smart ways to get maximized production and quality yields by deploying modern technologies. Today, because of the development of modern science and technology, people in cities are transforming progress from traditional agriculture to modern agriculture. Deployment of technologies to understand, monitor and control the needs of the crop is the key to the smart farming which is termed as greenhouse farming or urban farming. But land is the biggest constraint in urban cities. One smart solution to this is problem is using rooftop greenhouses in urban areas where plants are grown in a closed and controlled environment [2]. It is possible to get good yield in greenhouse when suitable environment for plants growth is provided. The requirements of temperature, humidity and light are not same for any plant for all the time periods [3]. But, People in urban areas can't provide sufficient water, sufficient light, appropriate temperature, adequate atmospheric surroundings and sufficient minerals regularly for plants in a rooftop greenhouse. Many people fail to get good profits from rooftop greenhouse as most of the time they are not able to regulate essential factors-humidity, soil moisture and temperature. Therefore it is necessary to accurately collect and control the greenhouse parameters to provide a suitable environment for the growth of plants. Combination of sensor, signal processing, control, communication and networking technologies are back bones of new smart farming technologies [4]. With these it is possible to monitor both the physical and environmental parameters, learn the optimized set of them needed for the particular flower/vegetable/crop, customize them and control them for better yield [5]. Hence WSN is adapted to green house farming for growing bell pepper/capsicum by monitoring and controlling temperature, humidity, soil moisture and light parameters. This WSN based automation becomes easy to maintain optimum levels greenhouse parameters by eliminating the need for manual intervention [6]. With this solution, it was possible to achieve 3-4 times higher yield in capsicum than that of outdoor cultivation in a short term cycle.

II. SYSTEM ARCHITECTURE

A. *Capsicum Needs*

In Urban market, colored capsicums are in great demand.

Figure 1. Colored capsicum [7]

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TABLE I. REQUIREMENTS FOR CAPSICUM CROP

Sl No.	Parameter	Requirement
1	PH	6.0 to 6.5
2	Soil	Highly Porous
3	Day Temperature	25-30°C
4	Night Temperature	18-20°C
5	Relative Humidity	50-60 %

In this regard, capsicum crop is chosen for study and experimentation purpose as shown in Fig. 1. Capsicum is a cold season crop, but it can be cultivated throughout the year using polyhouse/greenhouse. For capsicum cultivation, the pH of the soil should be between 6.0 to 6.5, soil should be highly porous and should be well drained so that the roots can be improved and the better penetration of the roots. Harvesting of capsicum fruit starts after 80-90 days from transplanting. Yellow and red fruits can be harvested when they receive 50-80 percent of the color development. The requirements for capsicum to get a good yield are listed in Table I [7].

B. *WSN System Description*

A Typical Wireless Sensor Network (WSN) includes few to several hundreds or thousands of nodes (Motes). The heart of Wireless Sensor Network (WSN) is the Sensor Node. Each of these sensor nodes are scattered in a sensor field and are capable of collecting the information, route data either to other sensors or back to an external base station [8]. Sensor nodes in the network should connect together and/or to the gateways in star, mesh, random and hybrid topologies on an adaptive basis. The wireless sensor unit has the components as shown in Fig. 2. The variation in soil qualities: PH value, Soil Moisture, Soil Temperature from one grow bag to another could be observed very commonly in the urban rooftop greenhouses. So, it is important to measure temperature, humidity and light in urban greenhouses.

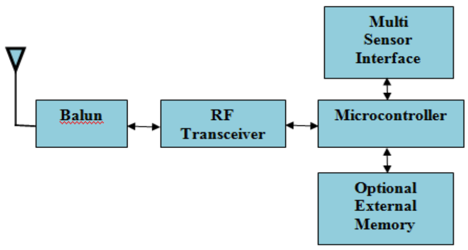

Figure 2. A wireless sensor node block diagram

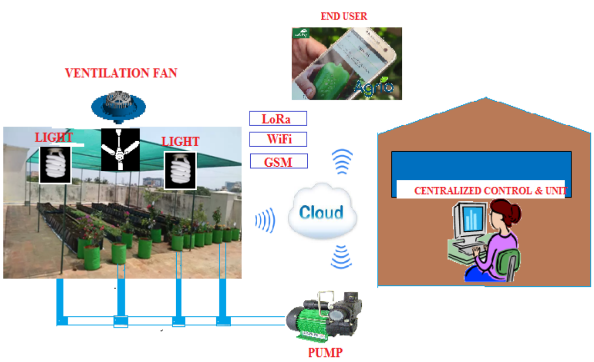

Figure 3. System architecture

A conceptual view of a roof top greenhouse of area 20X20 is shown in Fig. 3. This system has 3 main sections: Sensor section, Centralized Control Section and Data transmission Section [9].

A. *Sensor Section*

Sensor Section includes totally 3 types of sensor nodes: Two Humidity & Temperature Sensors-AM2302, Two Soil Moisture Sensor -YL-69 and Two Light Dependent Resistor -LM393 as shown in Fig. 4.

Humidity & Temperature Sensors: AM2302 (wired DHT22) is a temperature-humidity sensor as shown in Fig. 3 used to measure the presence of water in the air [10]. It is a basic low-cost digital temperature-humidity sensor to sense the surrounding air and generates digital signal on data pin. The microcontroller sends corresponding signal to the interface devices that turns on the fan to restore the greenhouse humidity and temperature.

Soil Moisture Sensor: Water supply is very important for a good growth of plants. So, the water level in a soil is detected using YL-69 as shown in Fig. 3. Two probes of soil-moisture-sensors are placed in soil. Soil moisture sensor sends signal to the microcontroller when it detects a lack of water in a greenhouse. The microcontroller sends signal to the corresponding devices to turn on the pump [11]. A notification is also sent to the owner with status of water pump like Motor On or Motor Off.

Light Dependent Resistor (LDR): LDR detects ambient brightness and light intensity. LM393 light sensor as shown in Fig. 3 is used to measure an ambient light. LM393 is a low-cost light sensor, equipped with a LDR (Light Dependent Resistor) and a comparator circuit. It sends the signal to the microcontroller if there is a lack of sunlight. The microcontroller sends the signal to turn on/off the lamps according to the sensor output [12]. Its switching threshold can be adjusted with a potentiometer. In LM393, D0 port output goes high when the external ambient light intensity exceeds a threshold value which is set; otherwise, D0 output goes low. Digital output D0 directly connected to the microcontroller, and detects high or low TTL, thereby detecting ambient light intensity changes.

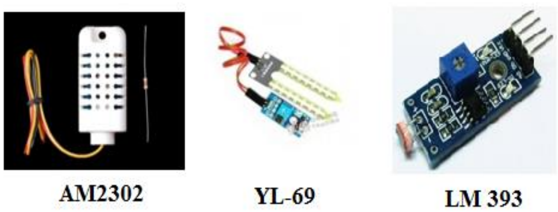

Figure 4. Sensor nodes

B. *Centralized Control Section*

Centralized Control Section includes actuators to activate local activities such as heating, lighting, ventilation in greenhouse [13]. When environmental parameters such as temperature or humidity become higher or lower than the set thresholds, some corrective actions are needed. It is able to automatically control the greenhouse climate by sending control commands.

C. Data Transmission Section

Data transmission Section controls the flow of data and instructions between Sensor section and Centralized Control section. It also manages the local activities such as turning on/off sprinkler, humidifier etc. It communicates with the sensor stations using ZigBee wireless protocol and is thus restricted to short distance links [14]. Data transmission Section processes incoming data, issues instruction to Centralized Control Section and Greenhouse station to control greenhouse environment.

III. Results & Discussion

To maintain climatic condition inside the greenhouse the temperature, humidity, LDR and soil moisture sensors are used to sense the natural climatic condition, whose output signals used by the microcontroller to control the climate. The program is written on to the microcontroller for the specific environment conditioning. The desired temperature and humidity are maintained by turning on heater/cooler. The moisture in soil is controlled by turning the water valve on/off. The desired light flux for that environment can also be controlled by using emergency lights when necessary. Thus, the greenhouse environment is controlled automatically in urban area. The sensor readings received from different sensors in this paper are listed in Table II and graphs are also listed. These sensor data could be stored for further analysis to identify the optimal climatic parameters for maximum yield in greenhouse farming. In the future, the growth of plants in different stages of growth could be monitored and proper ratio nutrients like Nitrogen (N), Phosphorous (P) and Potassium (K) must be used in a proper time. The sample data collected from different sensors are shown in Table II and graphs are plotted for the received data as shown in Fig. 5.

TABLE II. Sample Sensor Data Received

Sl no	Sensor_id	Updated_ time	Temperature (°C)	Humidity(%)	Light
1	Saaragrmk2.002	2/22/2017 6:00	20	56	891
2	Saaragrmk2.002	2/22/2017 12:00	32	24	904
3	Saaragrmk2.002	2/22/2017 23:30	24	24	14
4	Saaragrmk2.002	2/26/2017 6:00	19	88	905
5	Saaragrmk2.002	2/26/2017 12:00	29	33	901
6	Saaragrmk2.002	2/26/2017 23:30	22	73	11
7	Saaragrmk2.002	2/28/2017 6:00	17	83	899
8	Saaragrmk2.002	2/28/2017 12:00	29	20	895
9	Saaragrmk2.002	2/28/2017 23:30	21	53	12
10	Saaragrmk2.002	3/20/2017 6:00	23	83	928

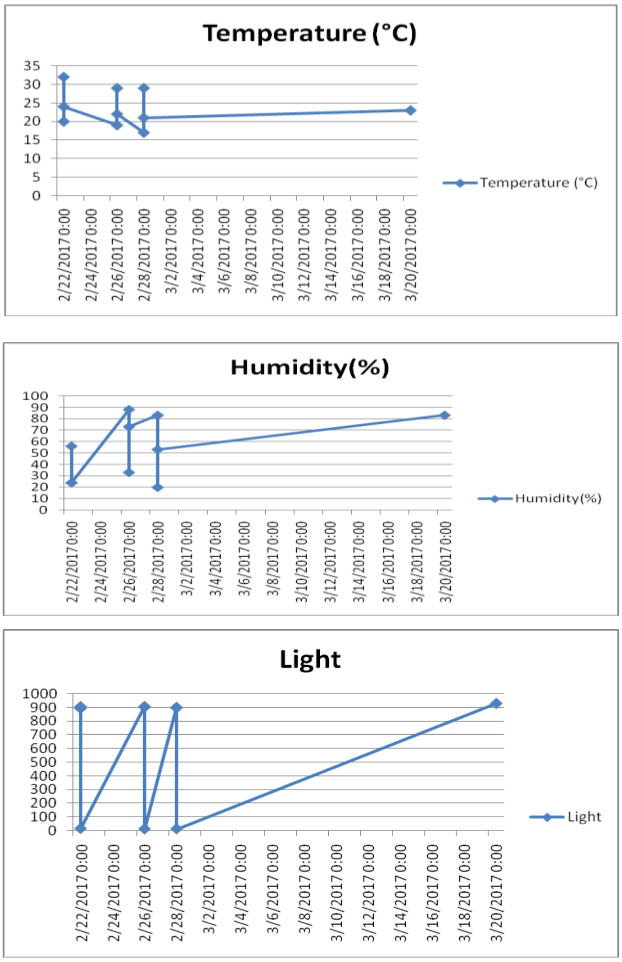

Figure 5. Moisture, soil temperature, humidity and light plots

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