Sustainable Agriculture using Eco-friendly and Energy Efficient Sensor Technology

Srisruthi.S, N.Swarna, G.M.Susmitha Ros, Edna Elizabeth

Abstract— **Agriculture requires the dedication of many natural resources, including land, water, and energy. The quality and quantity of these natural resources has degraded over the years due to various economic problems associated with increased cost of inputs, decreased farm incomes, ever declining land, labour, energy resources and also ecological problems such as soil, water pollution and soil erosion, putting the viability of future agricultural operations at risk. The remedy to this is to adopt sustainable agriculture which supports careful management and cultivation of crops involving less use of fertilizer, pesticides, calculated use of precious natural resources like energy, water through controlled irrigation and fertigation practices with the help of green sensor technology and electronic control systems. The paper provides efficient automated farm monitoring and irrigation techniques which incorporate wide range of sensors to remotely sense and monitor various parameters of the soil like temperature, moisture, fertility and regulate the supply of water and fertilizer to the land based on the requirement. An algorithm formulated with the threshold values of sensor outputs is used to code the microcontroller which performs the required actions by employing relays until the strayed-out parameter has been brought back to its optimum level. The cloud based user friendly interface facilitates real-time data logging of environmental parameters while also supporting analysis of past statistics for future growth by means of a web-based customizable application. Furthermore, the project aims to optimize the use of land and labour, conserve water, increase crop yield, avoid wastage of energy and provide maximum automation and benefit the society by adopting smart environment friendly technology to implement newer and sustainable ways of agriculture.**

Keywords— Sustainable agriculture, web interface, fertigation, energy conservation, green sensor technology

I. INTRODUCTION

In today's world, Agriculture and technology are the backbone of an economy. While agriculture makes significant contribution to the economic development of less developed countries, it is technology that steers the process of economic prosperity in developed countries. With the global population expected to reach 8 billion people in 2025 and 9.6 billion people by 2050, the nations of this world will have to double its current food production despite several barriers such as

- limited availability of land
- climatic changes
- fresh water requirement
- declining labour force
- energy crunch

etc, in fulfilling the demand. Climate change will have a huge impact on agriculture which include extreme weather conditions, intense storms and heat waves, floods, whilst water shortages in certain parts of the world could become acute. Agricultural progress is important not just to feed the increasing population but also to provide raw materials to industries and back the development of other sectors. Hence it must be understood that industrial and agricultural developments are not alternatives , but complementary to each other in the path to achieve food security. The variety of challenges faced by today's agricultural sector can be overcome by adopting sustainable or precision farming techniques with the help of technology. The IOT Internet of Things is a system or network of machines , objects or devices equipped with data-collecting techniques, so that the objects can communicate with one another. It can greatly contribute in the transformation of the agricultural sector by providing innovative tools for addressing the needs and drawbacks of conventional farming. Precision agriculture uses distributed sensor networks to collect data and effectively optimize crop yields and energy resource thereby moving closer to sustainability.

II. BENEFITS OF SUSTAINABLE AGRICULTURE

Sustainable approach to agriculture with the help of automation and sensor technology, benefits the society in the following ways

- conservation of water
- optimization of energy resource
- reduces the pressure on a small number of agriculturalists to provide more food.
- better crop yield
- pollution prevention
- economically beneficial for farmers
- eliminates human error
- time saving, accurate diagnosis of nutrient deficiency
- automation with low power consumption components

On the whole, smart farming refers to data gathering, data processing, analyzing and automatic control systems which when jointly orchestrated; optimize the farm productivity and profitability.

Srisruthi.S: Department of Electronics and Communication Engineering,SSN College of Engineering, Chennai, India

N.Swarna: Department of Electronics and Communication Engineering,SSN College of Engineering, Chennai, India

G.M.Susmitha Ros: Department of Electronics and Communication Engineering,SSN College of Engineering, Chennai, India

Dr.Edna Elizabeth: Department of Electronics and Communication Engineering,SSN College of Engineering, Chennai, India (arrswarna@gmail.com)

978-1-5090-0774-5/16/$31.00 © 2016 IEEE

III. COMPARISON OF VARIOUS MODELS

A stable agricultural sector ensures the food security of a county. However, it still remains a conservative sector, where innovation takes place at a slower pace than in other sectors, primarily due to the high costs involved with smart agriculture. The previous models make use of expensive sensors which can be replaced by cost effective ones without compromising on the efficiency. For instance, many open source smart agri-products use expensive soil pH sensors to measure the fertility of the soil while our system uses cheap colour sensors to identify the nutrient deficiency in crops simply by recording the colour of the leaves, thereby reducing the cost of the overall system. Furthermore, our proposed system provides an integrated network of multiple sensors to sense almost every parameter concerned with the growth of plants and a web-based customizable application which allows the user to monitor the farm from anywhere. Certain flaws in the sensing methodology of older models are also identified and corrected. The communication between the base station and the nodes are established using a WiFi module(ESP8266) whereas in other models it is done through expensive modules like Zigbee, Xbee, etc.

IV. PROPOSED AUTOMATED SYSTEM

The health of a plant is influenced by many factors such as humidity, soil moisture content, nutrient availability, exposure to light, amount of water/rainfall received, colour of the leaves, etc. The proposed system aims at conserving water and energy by using drip irrigation method and to monitor the plants by maintaining the optimum temperature and light intensity. Different sensors and actuators are being used to detect various parameters of the soil like moisture, temperature, pressure, humidity and light. When any of the above mentioned parameters cross a safety threshold which has to be maintained to protect the plants, the sensors sense the change and the microcontroller reads this from the data at its input ports. On sensing the change, the microcontroller then performs the required actions by employing relays until the strayed-out parameter has been brought back to its optimum level.

Each strip of plants/crops houses a node composed of:

1) Soil moisture sensor
2) Pressure sensor
3) Temperature sensor
4) Light sensor
5) Colour Sensor

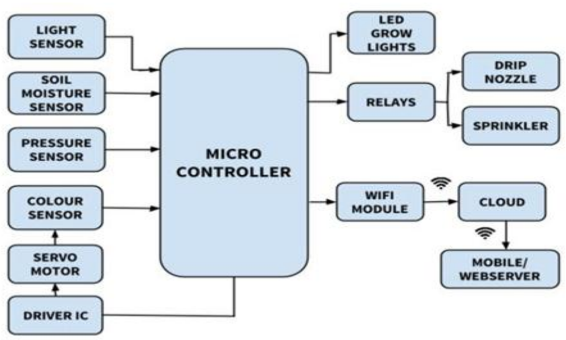


Fig.1: Block Diagram

The block diagram shows the input and output devices to the microcontroller. The input devices includes the sensors namely light, soil moisture, pressure, temperature and colour sensors. The output devices include led grow lights, relays to control valves and sprinklers, WiFi module to send required data to web server via internet.

A. Soil moisture Sensor

Soil moisture sensor measures the volumetric water content of the soil. Measuring soil moisture can help in efficient management of irrigation systems and can also help in increasing yield and quality of the crops. When the magnitude of the soil moisture exceeds a threshold value, the water flow is stopped or decreased depending on the value. Water is made available to the plants when the moisture content in soil goes below the threshold by initiating water supply using the relays/reed switches through the microcontroller.

B. Pressure Sensor

It is known that heavy showers can be expected when the atmospheric pressure is low and rainfall is less likely to occur when pressure is high. Rainfall is inversely proportional to atmospheric pressure. The pressure sensors connected to the microcontroller also regulate the water flow by stopping the supply when the pressure is lower than a threshold value. (The threshold value depends on the amount of rainfall received in the area of cultivation). The plants are watered using sprinklers or small nozzles. To avoid errors in pressure values due to external factors like animals or flapping of wings of birds, etc., the pressure value is determined by an average of pressure values taken from a number of sensors installed at different points in the field.

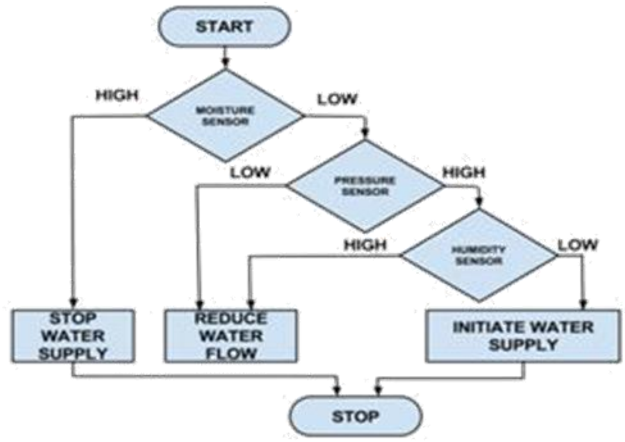


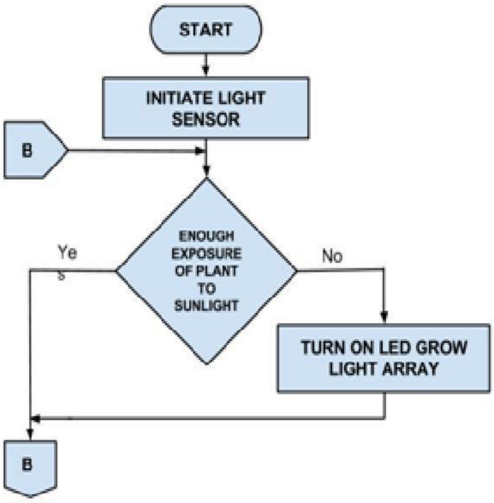
Fig.2: Initiation of water supply by moisture and pressure sensors.

A. Temperature sensor

It is a precision integrated-circuit temperature sensor and gives an output voltage proportional to temperature. Every 10mV increase denotes an increase in temperature 1 degree on Celsius scale. All plants need an optimum temperature for photosynthesis and growth. Temperature also affects seed germination, respiration, transpiration, flowering, dormant period, etc. The sensor reads the values and sends them to the user's webpage. The user can make efforts to control the temperature such as setting up a greenhouse or choose a cooler location for the grow space.

B. Light sensor

Light has three principal characteristics that affect plant growth: quantity, quality, and duration/photoperiod. Light quantity is the intensity or concentration of sunlight received by the plant. The colour or wavelength reaching the plant surface is the light quality. Light duration or photoperiod refers to the amount of time the plant is exposed to sunlight. The light sensors record the amount of light the plant has been exposed to and relays this information to the microcontroller. A Light-Dependent Resistor (LDR) or a Photoresistor is used as a light sensor. The supplemental LED grow light arrays which are placed in different positions of the field are then turned ON if sufficient amount of light has not been received by the plants. Reflectors are used to make sure the light reaches a large area and thereby, every plant so that a few LED arrays may be used.



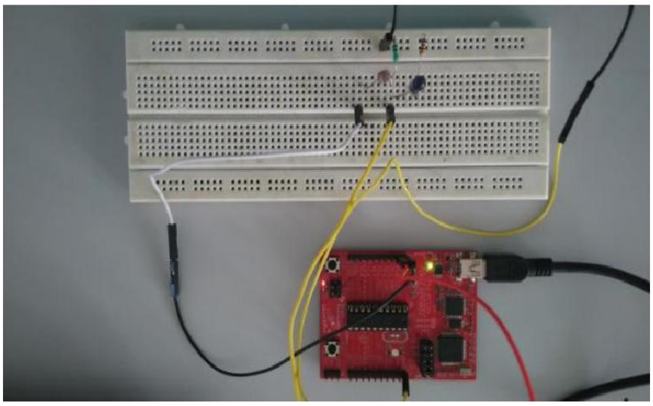
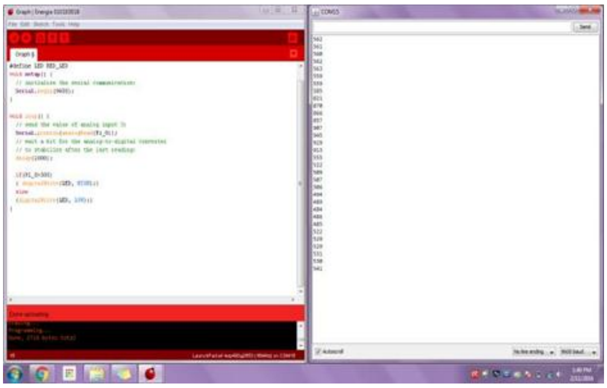


Fig. 4 :Experimental setup for Light intensity sensing using MSP430 microcontroller and LDR.



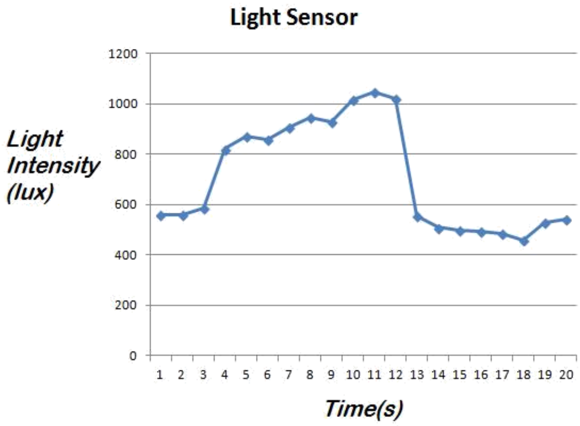


Fig.6: Time Vs Light Intensity Graph

This is a model graph whose light intensity values have been recorded under laboratory conditions, i.e., high light intensity and low light intensity were measured using a torch and a black surface respectively. In real-time when the light received by the plant goes below a threshold, LED grow lights are switched on. This was simulated in the laboratory by making an LED glow when the sensor value goes below a certain point.

C. Colour sensor

In most cases, the nutrient level of a plant can be determined by the colour of the leaves. The colour sensor that is fitted on a pod amidst the crops is made to rotate 360 degrees with the help of a servo motor to identify the colour of the plant leaves. (The typical colour of the leaves of the particular plant is considered to be the threshold). It is generally known that if the leaf colour is very dark, there is excess of fertilizer and hence fertigation to that part of the land is terminated for a certain period. Any variation of the leaf colour from the threshold is sensed and this data is then utilized to decide whether the plant needs fertilizer or not. Fertilizers are supplied by fertigation process using a drip system.

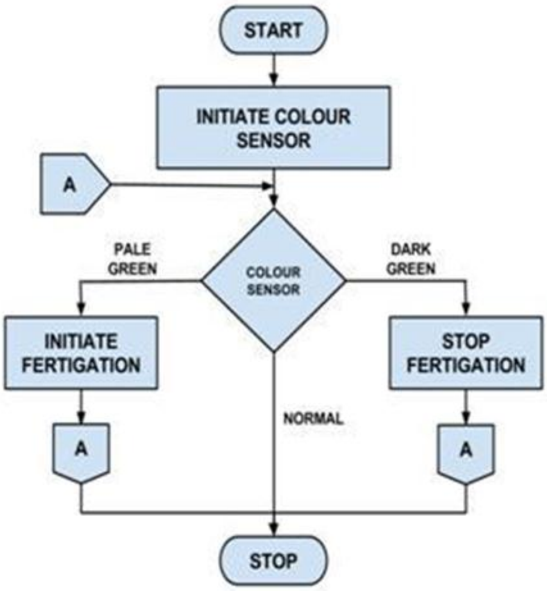


Fig.7: Initiation of fertigation by Colour sensor.

A. *Fertigation Technique*

One of the major hindrances to obtain the maximum yield is the degradation of the soil fertility of agricultural land due to the excessive usage of chemical and inorganic fertilizers and pesticides. Fertigation is a resource-saving technique where water-soluble organic fertilizers in ample quantities are blended along with the water that is used for irrigation. The mixture is stored in a reservoir and its flow can be controlled using relays. Drip irrigation or sprinkler irrigation is adopted in which the fertilizers are sprayed through drip nozzles or sprinklers in fluid form only in the root region. Nutrient and water absorption is greater in crops since they are supplied near the active root zone, thereby avoiding wastage of fertilizers and depletion of soil fertility.

TABLE I. Comparison of fertilizer efficiency

Nutrients	Soil application (%)	Fertigation (%)
Nitrogen	30-50	95
Phosphorous	20	45
Potassium	50	80

B. *MSP430*

The lowest power microcontroller currently available in the market is MSP430.The inherent low power operation is used in applications where frequent battery replacement is not possible. A 9V battery can power the MSP430 to function upto 10 months. Intelligent analog and digital peripherals can run autonomously in low power modes

TABLE II. Comparison of various controllers

Specifications	MSP430	Arduino	ATmega 328
Current drawn(sleep)	1uA	2.2mA	0.1mA
Current drawn(active)	700uA	40mA	16.43mA
Power consumed	2.52mW	200mW	81.8mW

The sensors at each node will be connected to the MSP430 via I2C bus to process the data from each of the sensors. The I2C (Inter-IC) bus is a bidirectional two-wire serial bus that provides a communication link between integrated circuits. The program of the sensor nodes collect the temperature, pressure, soil moisture, colour, light received and communicates with the launchpad through wireless module. The analog to digital convertor converts the analogvalues from sensors to digital inputs for the launch pad. These values are then compared with the predetermined threshold to accordingly operate the appropriate relays and valves. These values are also sent to a web server for data logging with the help of a WiFi module. The ESP8266 WiFi Module can give any microcontroller access to WiFi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. This module has a powerful enough on-board processing and storage capability that allows it to be integrated with the sensors and send the values to a web server. The data received by the host PC is displayed through a simple web page. The sensor nodes are given unique IDs through which the base station identifies the node. The clocks of the base station and nodes are synchronized for implementing this real time application. To facilitate easy monitoring and accessibility the web server will be connected to a mobile application. This can be done through cloud integration. A ‘cloud app’ is an app that performs its task on a webserver but delivers results to clients. The information to be delivered by the app includes the irrigation routine, ambient temperature around crops, etc so that the user can have a tab on what is going on in the farm in his absence.

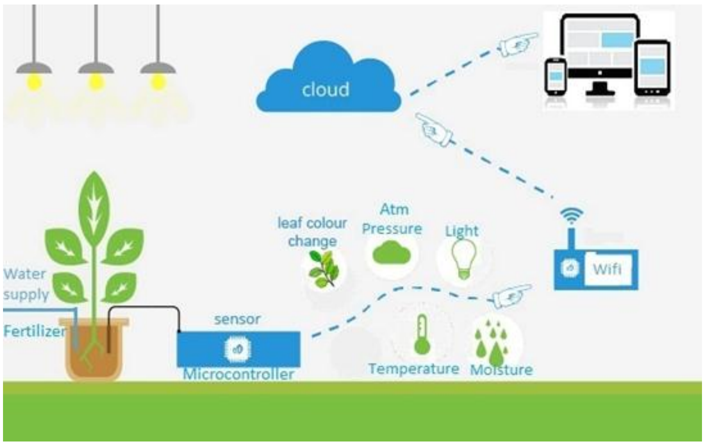


Fig.8: Schematic

VI. CONCLUSION

In comparison to industrialized agriculture, sustainable agriculture uses about 30% less energy per unit crop yield. Sustainable agriculture promises economic stability for farmers to lead a better quality of life. The concept of the connected farm is soon to be a reality and the introduction of smart technologies in the production stage of the agri-food chain can have positive environmental effects across the whole chain. A green, smart, user friendly infrastructure which provides autonomous decision making and control is the need of the hour. The proposed Microcontroller based automated drip irrigation system using wireless technique is a real time feedback control system which monitors and controls all the activities of drip irrigation system efficiently. The various other salient features of this project are:

1. It can be implemented in gardens or nurseries with minimum cost and resources.Also helps in proper utilization of the available resources and helps in avoiding wastage of electricity and water.
2. Can be easily configured and scaled up to work on larger fields.
3. Provides a user-friendly interface hence will have a greater acceptance by the technologically unskilled workers. The system is more compact compared to the existing ones, hence is easily portable and low cost.

Advancements in sensor technology and control systems allow for optimal use of resources. Our aim is to design and develop newer techniques that will allow garden automation to flourish and deliver to its full potential. Thus it can be concluded that the proposed project will lessen labour, conserve water, increase crop yield, provide maximum automation and benefit the society by adopting the fast growing IOT Internet of Things to implement newer and sustainable ways of farming.

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