Deployment of Soil Sensors in WSNs for Precision Agriculture

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***Abstract*--** Energy efficient scheme is a significant requirement of energy-constraint in precision agriculture. Transmission consumption dominates energy usage in wireless sensor networks in precision agriculture. In precision agriculture various parameters like temperature, moisture and soil salinity effects on crop yield. The sensor nodes are used hop to hop communication for data transmission of a specific area. MFC's provide limited power to work the sensor for a long term monitoring which are using bacteria's for generation of electrical energy with the composition of chemical reactions.

Keywords: *Precision Agriculture, Wireless Sensor Network (WSN), Soil Moisture, Soil Salinity, Bacteria, Fungal*

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I. INTRODUCTION

Wireless Sensor Network is the idyllic aspirant to offer efficient and cost-effectively viable solution for huge diversity of applications ranging from Underwater data collection, scientific ocean sampling, health monitoring, agriculture, environmental monitoring to military operations [1] [2]. The lately emerge Wireless Sensor Networks (WSN) technology has extend rapidly into an assortment of multidisciplinary field like agriculture and farming [3].

The enlargement of WSN in precision agriculture makes it probable to enlarge efficiency, productivity and profitability in numerous agricultural manufacturing system while minimize unintended impact on wild verve and surroundings [4]. India as developing country the involvement of the agriculture is determined in enlargement of the nation state. Most of the residents of the countryside depend on cultivation. Now a time it is facing numeral of challenges such as typical weather change, asymmetrical rainfall, scarcity of water, unavailability of electric clout for irrigation etc. [5].

Conventional approach of cultivation is incapable to crop with these ecological changes. Good control over ecological parameter can led to augmented yield of crop. Ecological parameters like temperature, humidity and moisture acting as vital job in escalation of the yield. A sustainable approach is requisite to sustain balance among these parameters and surroundings. Over last decade, technological progression such as appearance of WSN, geographical information system (GIS) and erratic rate control has led to enlarged curiosity and espousal in precision agriculture [6].

Nowadays, due to the scarcity of facts related to, soil content and it's types, quantity of fertilizers to be added, proper amount of irrigation and it's types which majorly depends on the soil porosity and its ability to retain the water, have become a vital concern for agriculture.

As high cost involved in testing and analyzing the soil, to increase the net outcomes of farming, can presumably be the biggest single reason for deterioration of soil quality. Also, less availability of soil testing labs creates hindrance to identify nutrients or soil chemical factors that restrict the growth of plants.

The sensor nodes used in precision agriculture are very sensitive to the vigour consumption.

Vigour assets that can be defined as constraint of the physical source is one of the major factors which creates uncertainties to state precision agriculture environment.

More vigour value is collected by the sensors and statistics broadcasted from sensor nodes to the base station. Due to variation in environmental conditions and vigour value collected by nodes, network configuration may be modified accordingly [7].

II. LITERATURE REVIEW

Deployment Technique of Sensor in Precision Agriculture

The sensor nodes have interaction with the environment where they are inserted. It captures information about it and combines among them and helped to do work which needs to be done for precision agriculture [8].

The sense data from the nodes are collected by the satellite station that seeks the data which is shown is shown in figure1.

We divide the precision agriculture farm into regular square sensor fields shown in the figure 1.

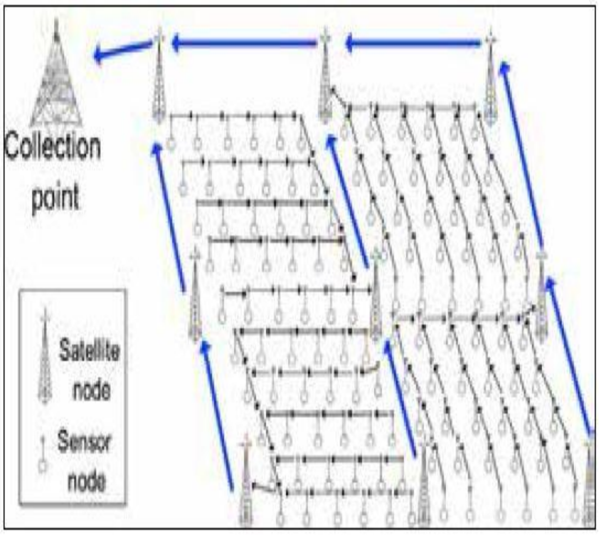

Figure 1. Network deployment in precision agriculture [8].

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Sensor motes are distributed in each field in a rectilinear form, with the square size 50mx 50m, and at a depth of 30cm. To save energy only neighbor nodes are able to communicate directly with each other. The satellite stations are located at the corners of each field. It has a transmission range of covering all the nodes in the field. The satellite station has 3 main operations but it does not perform any sensing operations.

- They relay the information to a base station which is collected from the sensor nodes in a field.
- They send routing and scheduling information to the sensors in the field.
- They contribute in the sensor localization process [8].

WSN Sensors in Precision Agriculture

Its major goal is to save the crops from fungal and bacterial diseases like "eyespot", "Pseudomonas Syringae", "Phomalingam", "LeptosphaeriaMaculans", "Alternaria-Dligst" and "Phytophthora". The ambience conditions like relative humidity and temperature are significant components to the spread of disease. So sensorsarepositioned in whole cultivate field to monitor the microclimate – the moisture or temperaturein a precise area, especially when this is diverse from the weather or temperature in the vicinity surrounding it can be closely monitored [9].

A. *Soil Moisture*

Acquaintance of moisture content acts as an imperative role in high yield of crop. A large extent of moisture in soil would influence the usage of N (Nitrogen) of the roots. At the similar instance the O_2 (Oxygen) at the roots will be inadequate. Each time of crop, different levels of moisture are required [10]. Soil moisture is the quotient of the quantity of moisture present in the entirety of soil. The amount of moisture contained by soil is indomitable by an alteration in the capacitance value and this further affect dielectric constant of soil [11].

Calculation of Soil Moisture

Probe is used to measure the dielectric permittivity of soil. It can be deployed at a depth from 1' to 3'.
The dielectric constant of soil is less than that of the water. Hence, any change in the moisture content of soil can have a significant change in the capacitance of soil.
To evaluate the soil moisture in different types of soils, soaring frequency is used by sensors. Following is the equation used to calculate the soil moisture [11].

$$C= \varepsilon_r \varepsilon_0 \frac{A}{D} \quad (1)$$

Where:-
C - Capacitance,
A - Overlapping area of the plates,
εr - Dielectric Constant of the material inside the plates,
ε0 - Dielectric Constant,
d - Distance between the plates

Equation (2) is used to demonstrate the development of potential between the plates.

$$C= \frac{q}{V} \quad \text{-----------(2)}$$

Where
C= Capacitance
q= Charge on Plates
V= Voltage between plates [11]

Specifications of Moisture Sensors

Figure 2: Soil Moisture Sensor (UFM-M11) [12]

Figure 2 shows the Sensor named as UFM-M1. It consists of 434*MHz*, low power wireless modules, with UGPA-434 omni-direction antenna. Outside radio broadcast, range of the module is 400 to 500m. Its power consumption is 10*mW* at 434*MHz* and current consumption is 17*mA* for receiving mode and 30*mA* for transmitting mode. RF wireless modules used to have communication on 9.6*Kbps* with MCU. Whereas, 60 bytes of data package can be sent to the transmitter module by MCU which is administrated by the Radio Frequency (RF) synchronizing protocol. Also, the module allows optimal working frequency (433.05 to 434*MHz* with 200*Hz* steps) [12].
Microcontroller used in sensor (PIC) runs by a 5V, the RF module runs by a 2.7 to 3.3V DC. The input voltage is passed through 1N4004 diodes for shielding against short circuit. The voltages level was kept as 5V with 7805 for PIC and 3.0V with LP2950 for RF module. The power supply of the system is discussed in Figure 3 [12].

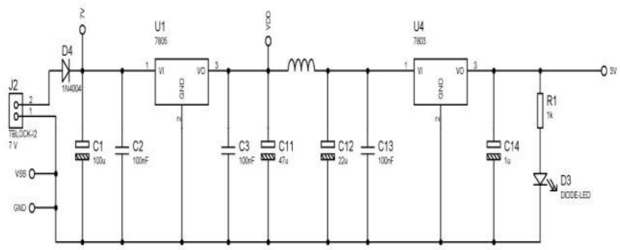

Figure 3. Diagram of the power supply

B. *Soil Temperature*

The soil temperature is one of the imperative environmental factors with a minor change of climate, topography, vegetation, soil type and planting form. The soil temperature is closely related to some processes, such as, crop planting time, growth of the plant and wintering safety etcetera. The change of soil temperature directly affects soil nutrient absorption and soil moisture content. Thus, the surveillance of soil temperature in real time and variation of soil temperature has a vital significance in the field of agricultural production and scientific research [13].

Specification of Temperature Sensors

The LM35 sensor series is a precision integrated-circuit temperature sensor. Its resultant voltage is linearly proportional to the Celsius (Centigrade) temperature. It is a low cost and small in size sensor. Its working temperature range is -55° to +150°C [14].

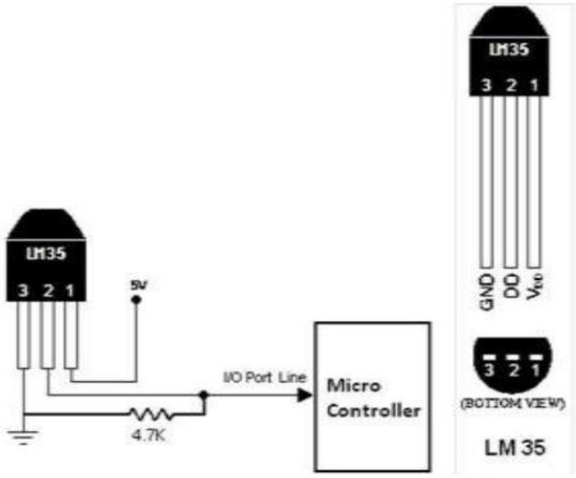

Figure 4. Temperature Measure Sensors [14]

C. Soil Salinity

Soil salinity degrades global agriculture by reducing crop yield and deteriorating soil quality. Biggest growing threat for the production of crops and sustainable agriculture can presumably be the soil salinity. Salinity can cause decreased plant growth, decreased yield and in drastic cases crop failure may be the result. Agriculture majorly depends on irrigation, such as, in arid and semi arid areas, the buildup of salt in soil profile is mainly controlled by evapotranspiration. Accumulation of salt on the surface of soil can result in degradation of soil quality and results in barren land [15].

Soil Salinity Sensors

Soil salinity sensor is used to monitor soil salinity very efficiently with minimum disturbance to the soil quality. Salinity, at selected depth, can be accurately monitored for a long period for intermediate-term monitoring. Soil salinity sensors consist of a pair of electrodes installed in a fine-textured ceramic element. Moisture which saturates the ceramic element becomes equilibrium with soil water to provide constant salinity measurement. One stainless spring is installed within the sensor to ensure good hydraulic contact between the sensor and soil. The sensor is designed to get accommodated crosswise into a 3.2cm diameter cored hole effectively, as shown in figure 5 [16].

Figure 5. Soil Salinity Sensor [16].

Specification of Soil Salinity Sensor

The dimension of probes of sensor is 68 long X 3 mm diameters (Centre rod 60mm) with housing: 55x45x12 mm. The power consumption of sensor various from 4 to 6 V and works on frequency on 20MHz. Soil sensor probe output for permittivity, ε' ranges from 1 to 80 with accuracy of± 2.5. Its bulk electrical conductivity, EC_b ranges from 0 to 300 with accuracy of ± 10 and sensor probe output temperature, ^{O}C ranges from -5 to 50 with accuracy of $\pm 1.5^{O}C$ [16].

III. Power Supply Used in Precision Agriculture:

To produce electrical energy from the environment electrochemically, MFC uses active bacteria. MFCs offer an uncomplicated, unswerving method for converting environmentally available biomass in form of electricity and also are very appropriate for sparkling, dispersed and renewable energy assets, for example, powering the sensors used in precision agriculture [17].

IV. Conclusion

This paper illustrates that importance of wireless sensor network in precision agriculture. In this paper author discussed the deployment technique of sensors in a specific agricultural area. Secondly, the author discussed the various parameters which will help in future to get a good quality of crop.
Thirdly, the author discussed about the energy resources for the sensor named as MFC (Microbial Fuel Cell) which will help to generate the power for the sensors.

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