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IOT: the Current Scenario and Role of Sensors Involved in Smart Agriculture

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Abstract*: Agriculture is a really important field for the economic development of any country. Most of the researchers are focusing on this field, by providing smart solutions for the day to day problem in field of agriculture. IoT (Internet of Things) has played a very essential role for the development of this sector, in fact IoT Technology has played a vital role in each and every field. IoT enables a working area in which everything works smartly and intelligently. IoT can be defined as a network of things which can make a self-configuring network. By developing new smart devices for the field of agriculture, it is converting the face of traditional farming to a new and intelligent level of agriculture production. IoT is not only enhancing the traditional agriculture to a smart agriculture but it enabling the new techniques for smart agriculture which are cost-effective as compared to the traditional agricultural tools. By the continuous monitoring of the processes and production it is also reducing the wastage of the crops. This paper aims to explore the various available techniques, methods, devices in the sector of the smart agriculture.

Keywords*: Smart agriculture, Internet of Things, Sensors, Sensor Node, Wireless Sensor Network.

I. INTRODUCTION

Agriculture is the process of cultivating crops and raising of livestock. The history of agriculture began thousands of years ago. In the beginning, it was done only for domestic purpose but as time passed new developments were made to enhance the production of the crops and hence people started earning from agriculture too. Agriculture can be divided into two parts:

- Industrialized agriculture – It involves production of crops and livestock in a huge amount by using industrialized techniques for the purpose of sale. The main aim here is to have increased production of crops so that they can be sold to large masses. It depends more on machinery than on manpower.
- Subsistence agriculture – It involves a farmer owning a small piece of land and growing crops on it to feed himself as well as his family. The main goal here is to produce enough yield so that the family can eat well. If there is high yield of crops then those can be sold in the local market.

Agriculture sector plays an important role in the process of economic prosperity of a nation. It has already made an amazing contribution in the economic development of developed nations and its huge role in the economic prosperity of the developing countries and the poor countries is of vital importance. It contributes to the economy of a nation in ways like:

- The non-agricultural sectors of economy get benefits from the agricultural sector because it provides food and raw material to them.
- Providing employment to masses whether they are skilled or unskilled.
- The export of agricultural products brings financial stability to the economy of a nation and hence creates demand for goods produced in non-agricultural sectors.

If the agricultural sector fails it adversely affects both the economy as well as an individual.In many parts of the world, farmers still use traditional methods to cultivate and harvest crops. This involves many disadvantages like:

- Less productivity.
- Crops quality is not good.
- Due to hard soil surface (less loosened soil), water and air are not able to penetrate into the soil.
- Roots cannot penetrate deep enough into the soil to soak up water and mineral salts.
- The crops produced using traditional methods are under nourished.
- After few rounds of productivity, the soil becomes non-fertile hence it is no more suitable for production of crops.
- The fertilizers (pesticides and insecticides) used are harmful for the crops as well as to the consumer of these yield of crops.

Latest techniques have been introduced to tackle these problems with aim of increasing the productivity and the quality of crops. New techniques are less labor intensive than the traditional ones as there is a greater reliance on machinery. Nowadays sophisticated technologies such as temperature, moisture, soil, pressure and wind sensors, robots, GPS technology etc. are being used. These techniques help in:

- More crop production.
- Decreased or limited use of water, fertilizer and pesticides.
- Negligible harm to the natural ecosystems.

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- Decreased runoff of chemicals into rivers, groundwater and many other water bodies.
- The workers can work quickly as well as safely.

Out of the several techniques available in the market, the techniques discussed here are IoT (Internet of things) and wireless sensor network. IoT is a network of physical objects of self-configuring nature which can collect and exchange data. The use of IoT solutions in agriculture is growing daily. Stats show that IoT device installations will hit 75 million by 2020, growing 20% annually. By 2025, the global smart agriculture market size will get tripled and reach 15.3 billion dollars. IoT can improve agriculture by:

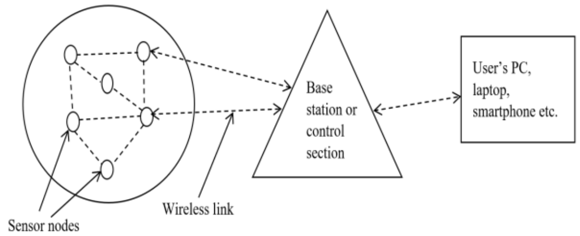
- Huge amount of data gathered by sensors/ sensor nodes: weather, soil, water level, crop's growth progress etc.
- Better control of production distribution. Exact yield of crops will be known and hence less wastage of the crops.
- Better business stability through automation processes like irrigation, fertilizing etc.
- Enhanced product quality and volumes.

These all lead to high revenue.

Next comes wireless sensor network. It is a self-configuring network consisting of a large number of sensor nodes where each node consists of a sensor to detect physical phenomenon such as light, temperature, humidity, wind etc. As the network is wireless, sensors are easy to deploy and are very much flexible in nature. WSN consists of sensor nodes, actuator nodes, gateways and clients. Sensor nodes collect data and transmit the data to a particular location or sink through gateway. Our main concern here is the sensor node. It consists of the power and power management module, sensors, microcontroller and a transceiver. The power module provides the power supply needed for the entire system to work efficiently. The sensor is the main part of a WSN which detects and responds to input from the physical environment. The microcontroller collects data from the sensor and processes it accordingly. The transceiver (transmitter and receiver) then transfers the collected data to a server through a gateway so that the physical realization of communication can be achieved. IoT and WSN gave rise to what is called "Smart Agriculture". Smart agriculture is a revolution in the agriculture industry that helps to develop and modernize the agricultural methods by getting rid of traditional ones and also guarantee food security during an ever-changing climate. The main focus of approaching smart agriculture is to increase agricultural productivity and incomes. The rapid escalation of food demand due to the growth in population led to the demand of smart agriculture.

II. WIRELESS SENSOR NETWORK IN SMART AGRICULTURE

The main purpose of using sensors in smart agriculture is to increase the overall crop productivity. Sensors help to sense various physical conditions like temperature, humidity, soil moisture, pH level of the soil, water level, air pressure, intrusion detection, water level etc. Doing this a user can increase crop productivity using minimum resources hence decreasing the overall budget of the system as well. Further, the sensors help the user in accurate use of irrigation, fertilizers, pesticides etc.



The figure above is the overview of smart agriculture using WSN which is divided into 3 parts: sensor nodes or mote, base station (control section) and the user end consisting of Internet or GSM enabled devices which can receive all the data gathered by the sensors with the help of which a user can analyze the data and hence can act accordingly. The sensors are deployed in the agricultural field.

III. LITERATURE REVIEW

Table 1 shown below is provided with the major findings of the researchers in the field of smart agriculture. Also, there will be table2 below which illustrates different sensors and sensor nodes used to make smart agriculture successful. With the help of this research background we are able to find the applications and adaptability of WSN in smart agriculture have been explored. An increased use of WSN in smart agriculture has been observed mainly for monitoring agricultural fields, best possible use of water for the crops without any wastage, measuring temperature and soil properties. Researchers have come up with many different tools/ techniques for smart agriculture using WSN. The various sensor nodes designed by the researchers have made the entire system smaller, easier to use and easily available as well. These sensor nodes can be used directly on the agricultural fields or in greenhouses to gather real time information about the growth of crops and the different environmental conditions like air humidity, temperature, soil moisture, soil pH level etc. Different sensor nodes like Mica2/MicaZ, TelosB, IRIS, SunSpot, WiSense etc. have the capacity to gather the required information, process it and finally transmit it for further analysis. Now, as we know the sensor nodes have onboard microcontrollers but few of the researchers still have used Arduino as a platform to integrate different sensors used is smart agriculture because of its ease of use and interfacing. But due to the various advantages of sensor nodes in WSN, these are being widely used in smart agriculture these days. Their ease of deployment makes them more demanding in the market plus the sensor nodes are cheap as well. Further, the sensor nodes in WSN can survive the harsh conditions in the agricultural field and can be accessed from anywhere in the world. But with advantages come few disadvantages as well like WSN is not fully secure, can be a victim of outside attack and has short battery life. Along with the factors discussed above, another important factor in smart agriculture is the presence of nutrients in the soil. For good growth of any crop, a total of 17 nutrients are required but of these 3 nutrients which are most important are nitrogen, phosphorus and potassium (NPK).

These are present in the soil in some ratio and any deficiency of one of these nutrients leads to poor quality of the crop. Farmers use fertilizers to keep a proper ratio or level of NPK in the soil. Smart agriculture aims at using minimum amount of fertilizers so that the cost of cultivation of a crop reduces.

Table 1: Study of different research papers in Smart Agricultur

Work done	Author	Year of publication	Tools/sensor/technique	Findings
A system based on WSN, GSM, and SMS technology.	Izzat Din Abdul Aziz et al. [1]	January, 2009	EZ430-RF2500 development tool, Temperature sensor	The system's purpose is to sense temperature and send it to the control panel where processing of the data is done. Further, a threshold value has been set so when the temperature is above this SMS alert is sent to the user's mobile phone. For the proper functioning of the system, several tests were done for good performance and better reliability.
A detailed and comparative study of wireless sensor nodes (motes) based on their performance metrics has been done and further a discussion on the issues related to them in terms of cost, size, and power has also been done.	Mridula Maurya et al. [2]	January, 2013	MicaZ, TelosB, IRIS, SHIMMER, TinyNode, Sun SPOT, Cricket, LOTUS	The performance metrics based on which the study has been done are - Physical characteristics, CPU, Speed, and Memory management, Transmit power level, Radio Range, Sensitivity, Power usages, and Supplementary Hardware and Software. After proper research, the mote which is best suited is the TinyNode based on its individual performance metrics. Further, IRIS and Sun SPOT are good as well.
The paper aims at making the best possible use of water for agricultural crops by effectively sensing the temperature and moisture parameters of the soil.	Joaquín Gutiérrez et al. [3]	January, 2014	IEEE 802.15.4, GPRS module (MTSMC-G2-SP), ZigBee module, PIC24FJ64GB004 microcontroller, Soil moisture sensor VH400, Temperature sensor DS1822	The system consists of WSN and WIU. The WSN does all the sensing part while the WIU transmits data to a web page using GPRS module for data analysis. The irrigation system works based on minimum soil moisture and maximum soil temperature to turn on the irrigation system for a desired period of time. The entire system has been powered by photovoltaic panels.

Discussed and compared different WSN (wireless sensor network) motes based on their qualitative parameters, computational and storage logic, software support, radio modules, onboard sensors and power source.	Sachin Gajjar et al. [4]	Febuary, 2014	TelosB/ Tmote Sky, MICA2/ MICAZ, SHIMMER, IRIS, Sun SPOT, eZ430-F2500T, Waspmotes	To have a clear idea about these motes, the simulations were done using MATLAB and the protocol used for these simulations was LEACH (low energy adaptive clustering hierarchy). To get the final result, average values were adopted.
A comprehensive survey of routing techniques in wireless sensor networks.	Rajesh Chaudary et al. [5]	June, 2014	-----	All of them have the common objective of trying to extend the lifetime of the sensor network, whereas on the other side also not compromise with data delivery. Generally, the routing techniques are divided into network structure and protocol operation-based routing protocols. In network structure, routing protocols are classified into three categories such as Flat based, hierarchical based and location-based routing protocols. Furthermore, some protocols are also classified into multipath-based, negotiation-based, query-based, coherent based, QoS-based and non-coherent based routing techniques based on the protocol operation.
A system to sense physical conditions like temperature, humidity and light using ZigBee sensor nodes and IoT for better crop production.	M. K. Gayatri et al. [6]	July, 2015	Temperature and humidity sensor DHT11	In this the local memory of a node has been updated with the information of various nodes present in the field . By doing this, detection of faulty sensors can be done and hence can be recovered manually. The collected data is then sent to data centers for further processing and also taking the decision whether the actuator should act autonomously or manually.

A survey on motes and application of the motes depending on their performance and parameters.	Ram Prasadh Narayanan et al. [7]	April, 2016	MICA2/ MICAZ mote, TelosB mote, Indriya-Zigbee Based WSN Development Platform, IRIS, iSense Core Wireless Module, Preon-32 wireless module, Wasp module, WiSense mote, panStamp NRG mote	He has shown the selection of a mote depending on factors like power consumption, redundant use, add your- own sensor(s), deployment area and node lifetime. Further, he has discussed RF modules based on power consumption and RF-related parameters such as transmission power and receiver sensitivity. In short, he has discussed how a mote can make a system automated even it requires more of human intervention.
'IoT based smart agriculture' which deals with the monitoring and controlling of field operations.	Nikesh Gondchawar et al. [8]	June, 2016	AVR Microcontroller Atmega 16/32, ZigBee module, Temperature sensor LM35, Humidity sensor DHT11, Obstacle sensor (ultra-sonic), Raspberry Pi, AVR studio, Proteus 8 simulator, Dip Trace, SinaProg, Rasbian operating system	It deals with on-field operations like weeding, spraying, moisture sensing, bird and animal intrusion, keeping crop security etc., and off-field operations like temperature and humidity maintenance as well as security of the warehouse. The proposed system is based on maximum temperature and minimum water level which means cooling fan gets activated when temperature is beyond a certain limit and water pump is activated when water level is below a certain level. The entire system has been remotely controlled by a smart device or computer connected to internet.
A platform designed named 'SmartFarmNet' uses automation to collect data of environment, soil, fertilizers, and irrigation.	Prem Prakash Jayaram et al. [9]	November, 2016	Soil sensor, Canopy temperature sensor, SmartFarmNet gateway	It filters out the invalid data and further can store that data in the cloud using SmartFarmNet gateway for further analysis of it. Furthermore, the advantages of this platform over the other platforms have been discussed. It allows the addition of any IoT device, sensor discovery, supports scalable data analytics and offers do-it-yourself tools that can allow farmers to analyze crop performance.

A system based on IoT for smart agriculture. It is a real-time monitoring system for keeping a track on soil parameters like temperature, moisture, pH level as well as the pest and disease identification.	Prof. K. A. Patil et al. [10]	December, 2016	Ubi-sense mote, IEEE 802.15.4, WINGZ	The sensing of various parameters is done using Ubi-Sense mote which consists of different sensors like temperature, relative humidity, light intensity, buzzer etc. The sensed data (properties of soil, crops and environmental conditions) is gathered at the server and is further used for analysis. Web application or mobile application on an android OS can be used by a user to receive and analyze the sensed data.
A remote monitoring system for agriculture based on WSN, ZigBee, and GPRS networks.	Zenglin Zhang et al. [11]	February, 2017	IEEE 802.15.4, CC2430, Soil moisture sensor TDC220, GPRS module, ARM9 processor, S3C2410, CC2420 RF module	The system design consists of sensor nodes that collect the soil moisture content information and sends it to the base station using ZigBee technology where the entire data is collected. Later, data is sent to the remote monitoring center through the base station so that data analysis can be done conveniently by a user. The system effectively helps in proper irrigation according to the collected data by WSN as well as helps in saving of water.
Its main aim is to make a smart agriculture monitoring system using automation and IoT technologies.	Dr. N. Suma et al. [12]	February, 2017	PIC16F877A-microcontroller, GSM module, Buzzer, Soil moisture sensor, Temperature sensor LM35, PIR sensor, Proteus 8 simulator	The work of sensing various conditions like temperature, moisture and water level is done here. The main controller of the entire system is the control section which works based on the threshold values. The system works in manual as well as automatic mode. The buzzer used here shows the warning sign and this warning or alert is sent to the user using a GSM module.
An IoT based monitoring system in smart agriculture.	Prathibha S R et al. [13]	March, 2017	CC3200, Temperature infrared thermopile sensor TMP007, Humidity sensor HDC1010, Camera sensor MT9D111	The aim here is to monitor temperature and humidity in agricultural field using sensors and in addition to this a camera sensor has been used to capture images and send them to a farmer via MMS so that they can know the condition of their crops.

A smart water dripping system for agriculture/ farming which means basically to control the watering of crops.	Priyanka Padalalu et al. [14]	April, 2017	Arduino pH level sensor, Temperature sensor, Moisture sensor SM300, Water pump, Servo motor, Web-scraper	The system consists of sensors to sense the conditions of the crop soil and with the help of predefined values, it decides whether the pump used in the system should be in on or off state. If there is a failure to water the crops, an alert is sent to the android application. In the case of natural conditions like rainy season, the weather conditions are also taken into account because that is the time when there is less need for smart irrigation. The microcontroller used here is Arduino which helps in less consumption of power supply. The entire system can be controlled using a smartphone.
A system based on IoT and WSAN to sense conditions like temperature, humidity, moisture, and light intensity as well as control the watering and roofing system.	Mohit Kumar Navinay et al. [15]	April, 2017	-----	He has used Kalman filter to get more accurate sensed data which is otherwise less accurate because of the presence of noises. He further has used a set of decision rules based on both sensed data and weather conditions to control the automatic working of the watering and roofing system. These two systems can be controlled manually too. Proper care of the irrigation system has been taken while keeping in mind the consumption of water required. Cloud computing has been used to store a large amount of sensed data.
Discussed the application of sensor motes and IoTs in environmental monitoring. It depicts the real-time monitoring of the environment.	K. S. Srijan et al. [16]	June, 2017	Temperature sensor LM35, Pressure sensor FSR, Humidity sensor DHT11, Accelerometer sensor ADXL 335, ZigBee transceiver, Web server	The environmental conditions like temperature, relative humidity, pressure, and angle have been monitored in real time using sensors. Further, the Zigbee protocol has been used to transmit and receive the collected data. The system proposed is energy efficient as the system works only when required otherwise it remains in standby or sleep mode. The IoT module has been used to view and analyze the collected data using a web server that stores data for a regular interval of time.

A smart farming using automation and IoT technology. The aim here is to make best possible use of water (smart irrigation), monitor fields, sense soil content and perform various other crop beneficial methods like spraying of fertilizers, pesticides etc. A smart warehouse management system has also been proposed.	Amandeep et al. [17]	October, 2017	Temperature sensor, Humidity sensor, Moisture sensor, Ultra-sonic obstacle sensor, AVR microcontroller Atmega 16/32, ZigBee module	A proper care of irrigation has been taken so that there is no wastage of water. The processes involved after harvesting like storage and security of yield in the warehouse have also been taken care of. The warehouse consists of room heater and cooling fan to maintain the temperature inside as well as water pump to keep proper level of moisture in the soil. The security of the warehouse is also taken into account by using ultra-sonic obstacle sensor which can easily detect any intrusion in the warehouse.
A smart system based on IoT for monitoring the agricultural field and providing water to it using smart irrigation system.	R. Nageswara Rao et al. [18]	January, 2018	Raspberry-pi 3, IC3208, Soil moisture sensor, Temperature sensor LM35, LM358, Relay, Buzzer	The sensed data (temperature and humidity) in the form of analog values is firstly converted to digital values and then processed by raspberry-pi which is finally sent to the database after which starts the use of the irrigation system once the sensed data is properly analyzed.
A system has been proposed for smart farm using existing technologies like IoT and wired communication method based on Arduino.	Chiyurl Yoon et al. [19]	February, 2018	Arduino, Sensor nodes, IEEE 802.15.4e, MQTT, LPWAN module, Bluetooth module	The system consists of nodes, gateways, servers, databases, and smartphones. He has used a blend of wired, wireless and IoT dedicated technologies for the transmission of the collected data from the nodes to the servers. He has come up with a way to keep power consumption less by using low power communication modules. The problem of data loss due to the use of wireless transmission and reception of the collected data has been overcome by transmitting the identical data 10 times so that each bit is received.

This work is based on a smart irrigation system using IoT with a humidity sensor. The aim here is to check the moisture level of soil and hence make best use of the irrigation system.	Dweepayan Mishra et al. [20]	February, 2018	Soil moisture sensor, Arduino	A threshold value has been set according to which the smart irrigation will take place. The irrigation being automatic in nature pumps water to the crops accordingly. The crops can be irrigated using the minimum amount of water.
An IoT network for smart agriculture using less power and less cost.	Soumil Heble et al. [21]	February, 2018	IITH mote, Solar irradiance sensor 6450 TSR, Temperature and humidity sensor DHT11, Light intensity sensor BH1750, Carbon dioxide sensor CDM4161A	The sensors used here sense 6 different parameters (soil moisture and temperature, light intensity, relative humidity, ambient temperature, carbon dioxide, and total solar radiation) and send all the collected data to sink which uploads the data to the server for further processing and analysis. The sensor nodes are solar powered thus consuming less power and making the overall cost of the entire system very less.
A smart agriculture system for proper utilization of water and also keeping a track of unwanted entry of animals in the crops field.	G. Sushanth et al. [22]	March, 2018	Arduino, Temperature sensor, Humidity sensor, Soil moisture sensor, Motion sensor, Wi-fi module ESP8266, GSM module	The entire system is based on IoT, WSN and cloud computing. The smart irrigation system works according to users' input to have the best possible use of water. The system here works in three phases – sensing, processing and information distribution. The collected (sensed) data is sent to a micro-controller (Arduino) for processing and with the help of gateway the data is uploaded to cloud which allows user to keep an eye on the parameters like temperature, relative humidity and soil moisture from anywhere possible using a mobile application. Motion sensor helps in reducing the intrusion of animals by sending an alert to the farmer on his/ her smartphone.

A system has been proposed based on WSN for smart indoor agriculture.	Gourab Panda et al. [23]	May, 2018	Soil moisture sensor, Temperature sensor, Air humidity sensor DIY HR-202, Light intensity sensor LX1972, Arduino board, Solenoid valve	Instead of using more than one sensor nodes only one sensor node has been used to detect parameters like soil moisture, temperature, relative humidity, and light intensity. It also makes the entire system smaller in size. The system proposed is for indoor agriculture product monitoring for the people of the urban region. The main aim here is to collect data, process it and route it to the gateway through a router which further sends this data to a laptop or a personal computer. Data visualization has been done which converts the raw data into a suitable one which can be easily understood by any user.
A system based on IoT to overcome the traditional methods so that the production of good quality and quantity of crops can be achieved.	Waleed Abdallah et al. [24]	June, 2018	Temperature sensor, Humidity sensor, Soil sensor, Arduino, Database server	The sensors used here obtain data from the crops present in the greenhouse. This data is transmitted due a central control system using RF communication system. The data is stored in database for analysis which can be accessed from anywhere by a user using a mobile application. Further, the positive results of using these modern-day techniques have been discussed.
This work is based on IoT in which after sensing the soil parameters, water can be provided to the crops using smart irrigation. All this is done to increase crop production, reduce the cost of the yield and have the best possible yield.	Jirapond Muangprathub et al. [25]	January, 2019	Soil moisture sensor, Solenoid valve, Temperature and humidity sensor DHT22, NodeMCU, Web server	The data collected by the IoT devices in the control box is gathered and analyzed by a user in the web-based application. The data is analyzed thoroughly to know the water requirement of the crops. The mobile application being used by a farmer is finally used to control the water supply. It can work in both manual as well as in automatic mode.

Sensors/ Sensor nodes are compact in size, cheap and easily available. A sensor node mainly consists a microcontroller, transceiver, power source, memory, ADC (analog-to-digital converter) and finally one or more sensors. The microcontroller (other controllers which can be used are desktop microprocessors, digital signal processors, FPGAs and ASICs) is the brain of the sensor node which processes all the data sensed by the sensors and also controls the functionality of the components present in the sensor node. The transceiver (mostly uses ISM band because of its free availability) transmits the collected data as well as receives the data to and fro from the base station or control section using wireless transmission media like RF (radio frequency), optical communication (laser) and infrared. The sensor node requires power for sensing, communication and data processing so the power source supplies enough power to the entire system for it to function properly. The memory (RAM, flash memory and EEPROM) is used to store the user data and also the program which is used for programming the device. The ADC converts the gathered analog data to a suitable digital data which can be easily read by the user. Finally, the sensors produce a measurable response to any physical change that occurs around them. Conditions like temperature, humidity, pressure etc. are easily sensed or detected by the sensors.

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Table 2: Sensors and Sensor Nodes Used in Smart Agriculture

Sensor (S)/ Sensor node (SN)	Cited	Parameters	Description
Mica2/MicaZ (SN)	[2] [4] [7]	Light, temperature and relative humidity sensor	Mica2/MicaZ have the Atmel ATmega 128L microcontroller. The Mica motes lack the presence of onboard sensors. But sensors can be directly connected to these motes by using the set of sensors provided by Crossbow. Mica2/MicaZ motes use 2 AA in an attached battery pack. RAM – 4K, Flash – 128K, EEPROM – 512K
TelosB (SN)	[2] [4] [7]	Light, temperature and relative humidity sensor	TelosB has the TI MSP430F1611 microcontroller. It is used in low power consumption researches. It is powered using an external battery pack of 2 AA. RAM – 10K, Flash – 48K, EEPROM – 1M
IRIS (SN)	[2] [4] [7]	Light, temperature and relative humidity sensor	It uses the Atmel ATmega 1281 microcontroller. It doesn't consist of onboard sensors just like MicaZ but sensors can be connected to it externally. It uses 2 AA batteries. RAM – 8K, Flash – 640K, EEPROM – 4K
SunSPOT (SN)	[2] [4]	Light and temperature sensor	It consists of Atmel AT91RM9200 microcontroller. It contains onboard sensors and uses 3.7 V rechargeable 750 mAh lithium-ion battery. RAM – 512K, Flash – 4M, EEPROM – none
WiSense (SN)	[7]	Temperature and humidity sensor	It uses the MSP430G2955 microcontroller. It uses 3V lithium coin cell or a pair of 1.5V AA/AAA batteries in series to function. The power supply to it is given externally. RAM – 4K, Flash – 56K, EEPROM – 128K
VH400 (S)	[3]	Soil moisture sensor	It is a low power consuming soil temperature sensor which also works as a water level sensor. It helps to save water and ignores the salinity factor of the soil when sensing the soil moisture.
DS1822 (S)	[3]	Temperature sensor	It is a digital thermometer having an operating temperature range of -55^0 C to +100^{0}C. It is a 3-pin sensor which provides ± 2^0 C accuracy.
DHT11 (S)	[6] [8] [16] [21]	Temperature and humidity sensor	It operates from 3.5 to 5.5 V. Its temperature range is 0^0 C to 50^0 C and its humidity range is 20% to 90%. Accuracy provided by a DHT11 sensor is ±1^{0}C and ±1%.
TMP007 (S)	[13]	Temperature sensor	It is an infrared temperature sensor which means it detects temperature of an object from a distance by absorbing IR waves emitted. It operates from 2.5V to 5V.
HDC1010 (S)	[13]	Humidity and temperature sensor	It is a digital humidity sensor with an integrated temperature sensor. It operates from 2.7V to 5.5V. it has a relative humidity accuracy of ±2% and a temperature accuracy of ±0.2^0 C.

MT9D111 (S)	[13]	Camera sensor	It is a 2-megapixel camera sensor which operates from 2.5V to 3.1V. It has integrated auto focus and optical zoom. Full resolution – 1600 × 1200 pixels (UXGA) Pixel size – 2.8µm × 2.8µm Maximum frame rate – 15 fps at full resolution and 30 fps at preview mode
SM300 (S)	[14]	Soil moisture and soil temperature sensor	It has moisture accuracy of ±2.5% and temperature accuracy of ±0.5^0 C. It operates from 5V to 14V.
LM35 (S)	[8] [12] [16] [18]	Temperature sensor	Its operating temperature range is -55^0 C to +150^0 C. It operates from 4V to 30V. Its temperature accuracy is ±0.5^0 C.
CDM4161A (S)	[21]	Carbon dioxide sensor	It operates at DC 5V±0.2 V. Its detection range is from 400 to 4000ppm.
DIY HR-202 (S)	[23]	Air humidity sensor	It is used for detection of humidity of surrounding environment. Its operating range is: humidity (20% -95% RH) and temperature (0^0 C - 60^0 C). It operates from 3.3V to 5V.
DHT22 (S)	[25]	Temperature and humidity sensor	It uses a capacitive humidity sensor and a thermistor to measure the surrounding conditions. It operates from 3V to 5V. Its humidity range is from 0% to 100% with 2 to 5% accuracy while its temperature range is from -40^0 C to 80^0 C with ±0.5^0 C accuracy.
LX1972 (S)	[23]	Light sensor	It is a silicon light sensor with nearly human eye spectral response. Its illumination range is from 1-800 lux. It operates from 3V to 5.5V.

The sensor nodes (Mica2/MicaZ, TelosB, IRIS, SunSpot, WiSense) mentioned above are commonly used in smart agriculture. These compact sized sensor nodes consume less power and collect all the required data to process and transmit it for further analysis by the user. The various sensors mentioned above can be used along with the sensor nodes because sensor nodes like Mica2/ MicaZ and IRIS do not have the presence of onboard sensors.

IV. CONCLUSION

This paper has presented a general information on the use of WSN using various sensors and sensor nodes available for smart agriculture. Still in many parts of the world, people are not aware of WSN which can be beneficial for them in enhanced production of crops using minimum resources. The monitoring of the fields, detection of environmental conditions and the automated irrigation/ dripping system using WSN are the needs of the hour (high in priority) to improve the agricultural system. It is concluded that, with so many advantages of WSN it is clear that there is more need of WSN in the sector of agriculture. More developments can still be made in WSN to achieve more success in smart agriculture.

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