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Monitoring for Precision Agriculture using Wireless Sensor Network-A Review

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Keywords : WSN, soil moisture, soil temperature, humidity etc.

GJCST-E Classification : C.2.1

MONITORING FOR PRECISION AGRICULTURE USING WIRELESS SENSOR NETWORK-A REVIEW

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Monitoring for Precision Agriculture using Wireless Sensor Network-A Review

Anjum Awasthi [α] & S.R.N Reddy [σ]

Abstract - This paper explores the potential of WSN in the area of agriculture in India. Aiming at the sugarcane crop, a multi-parameter monitoring system is designed based on low-power ZigBee wireless communication technology for system automation and monitoring. Real time data is collected by wireless sensor nodes and transmitted to base station using zigbee. Data is received, saved and displayed at base station to achieve soil temperature, soil moisture and humidity monitoring. The data is continuously monitored at base station and if it exceeds the desired limit, a message is sent to farmer on mobile through GSM network for controlling actions. The implementation of system software and hardware are given, including the design of wireless node and the implementation principle of data transmission and communication modules. This system overcomes the limitations of wired sensor networks and has the advantage of flexible networking for monitoring equipment, convenient installation and removing of equipment, low cost and reliable nodes and high capacity.

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I. Introduction

Nowadays, agriculture needs tools and technology to improve the efficiency and quality of production and reduce the envirnomental impact on the crop. The wireless sensor network in agriculture may bring out the fundamental contribution to precision agriculture. The precision agriculture is defined as the technique of applying the right amount of input (water, fertilizer, pesticides etc.) at the right location and at the right time to enhance production and improve quality, while protecting the envirnoment [1].

A wireless sensor network is a collection of nodes organized into a cooperative network. Each node consists of processing capability. It consists of one or more microcontrollers, CPUs or DSP chips, may contain multiple types of memory (program, data and flash memories), have a RF transceiver (usually with a single omni-directional antenna), have a power source (e.g., batteries and solar cells), and accommodate various sensors and actuators. The nodes communicate wirelessly and often self-organize after being deployed in an ad hoc fashion.

II. Problem Definition

It is observed that farmer bear huge financial loss because of wrong prediction of weather and incorrect irrigation method to crops. With the evolution of WSN now it is possible to use them for automatic envirnoment monitoring and controlling the parameter of field for precision agriculture application.One of the major problems present today is the less knowledge of the soil content & types, less knowledge of the type of fertilizers to be added, the irrigation amount and pattern depending on the soil porosity and its water retention capacity. In the current Indian scenario analysis of soil to increase crop yields is not being used to a large extent primarily due to the cost involved and the inaccessibility of labs offering such testing facilities. Moreover due to large size of land the procedure of sending soil samples to a lab would not represent the whole land.

In Wireless Sensor Network (WSN) the sensor nodes are very much sensitive to the energy consumption. The success of the wireless sensor network applications highly depends on the reliable communication among the sensor nodes. One of the major problems in WSN environments is the limitation of the physical resource that is energy resources. More energy is consumed in transmission of data from sensor nodes to the destination that is the base node. Due to change in environmental conditions and energy available with nodes there may be change in network structure; therefore dynamic clustering is essential. Apart from existing protocol, improved protocols are needed so that energy consumption can be reduced and overall performance can be improved.

III. Literature Review

The proposed irrigation management system in [1] using intelligent humidity sensor and low power wireless Trans receiver to collect the data and record SWT for facilitating irrigation management. The monitoring device used in this paper is laptop/computer or PDA. The processed SWT data make it possible to determine soil moisture trends and to predict or modify irrigation schedule for better crop yield.

The proposed system in [2] i.e. automatic irrigation controller is open loop, automatic and adaptive. This system determines the soil moisture and necessity of water to crop in order to supply just the right amount of water just enough to maintain moisture level. A microcontroller is used to control the operation along with relay switch and pump.

The proposed system in [3] uses the sensor node that include JN5121 module, an IEEE

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802.15.4/zigbee wireless microcontroller. The sink node for data aggregating was based on ARM9. GPRS gateway was used for long distance data transmission. The mobile unit was used as monitoring device.

The proposed system in [4], a study of zigbee based wireless sensor network in agriculture was carried out. This paper has reviewed few issues regarding zigbee in agriculture. That how the factors like node spacing, antenna height, crop canopy and density of leaves affects the signal strength.

The energy efficient WSN for agriculture proposed in [5] uses the sensor node equipment with CC1110 system on chip with low power RF Tran's receiver and 8051 MCU from texas. A CC 1110 evaluation module plugged into smart RF04 evaluation board who's LCD and LED buttons are readily available for monitoring and control. The hardware allows radio transmission in multiple power levels and also allow user to change receiver sensitivity. To compare the performance of PDMAC with SMAC, the behaviour of two nodes, a sender and a receiver was simulated using TOSSIM.

The proposed design of node system in [6] [7] uses the CC2420 zigbee/RF module as RF Tran receiver core unit of wireless communication system and MSP430 as microcontroller unit. The RF module is connected to SPI through MCU. The system also includes the communication web server, the centre of monitor based on web, expert system of agriculture. So the real time data connected through the sensor node is transferred to the sink node and then the information can be uploaded to the real time data base on the internet by GPRS.

The proposed system in [8] also includes the camera nodes and cattle sensor network along with the soil moisture sensor. To attach the sensor nodes to cattle, custom collars were created.

The paper [9] has proposed and analysed the use of programmable system on chip technology as a part of WSN to monitor and control various parameters of green house. In this CC3271 PSOC is used which is the first touch starter kit with low power RF with low cost USB thumb derive kit including related IDE software for sense and control of the data collection. It consists of PC dongle with RF and multifunction board with power amplifier and two battery boards. It can be used as touch sensing, temperature sensing, light sensing and proximity sensing requirement of green house.

The instrument in [10] [12] [13] is designed to monitor the soil temperature and humidity of agriculture environment. The tests were done to verify the reliability and accuracy of the temperature and humidity monitoring system. Two different sets of test were conducted i.e. in close room and open room environment [10].

The position estimation of sensor nodes in WSN for precision agriculture generally include errors and it is concluded that the average value of localization error decreases with the signal propagation coefficient and proved that the robustness of NMDS (non metric multi-dimensional scaling) algorithm for bad environment [11].

This paper [14] proposed a field signals monitoring system with wireless sensor network (WSN) which integrates a System on a Chip (SoC) platform and Zigbee wireless network technologies in precision agriculture. The wireless-network acquiring system is the MCU in which the Sunplus SPCE061A and signee module 3160 is used along with web server.

In this study [15], a fringing electric field (FEF) – capacitance based wireless soil moisture sensor has been designed, fabricated and tested to measure the volumetric water content (VWC) of soil for application in precision agriculture. Typically, the performance of the sensor is evaluated based on parameters such as penetration depth, signal strength, sensitivity and linear response.

To satisfy the needs of modern precision agriculture, a Precision Agriculture Sensing System (PASS) is designed in [16], which is based on wireless multimedia sensor network. The system is designed for sensing in wide farmland without human supervision. A dedicated single-chip sensor node platform is designed especially for wireless multi-media sensor network. To guarantee the bulky data transmission, a bitmap index reliable data transmission mechanism is proposed. And a battery-array switching system is design to power the sensor node. The effectiveness and performance of PASS have been evaluated through comprehensive experiments and large-scale real-life deployment.

The aim of the [17] is to review the technical and scientific state of the art of wireless sensor technologies and standards for wireless communications in the Agri-Food sector and it focuses on WSN (Wireless Sensor Networks) and RFID (Radio Frequency Identification), presenting the different systems available, recent developments and examples of applications. These technologies are very promising in several fields such as environmental monitoring, precision agriculture, cold chain control or traceability.

The results of real deployment of A2S [19], which consists of WSN(Wireless Sensor Network) to monitor and control the environments in green house with melon and cabbage in Dongbu Handong Seed Research Centre and a management sub-system to manage the WSN and provide various and convenient services to consumers with hand-held devices such as a PDA. A2S was used to monitor the growing process of them and control the environment of the green houses.

The paper [20] also describes a real-deployment of WSN based greenhouse management which is designed and implemented to realize modern precision agriculture. The proposed system can monitor the greenhouse environments, control greenhouse equipment, and provide various and convenient services to consumers with handheld devices such as a PDA living a farming village.

Cluster based routing algorithm is proposed in [21] [22] to reduce energy consumption of node transmitting data. The application of wireless sensor networks (WSN) to precision irrigation system is explored based on the acoustic emission principle for crop water stress [21]. The paper [22] proposes a new type of routing protocol for WSN called PECRP (Power-efficient Clustering Routing Protocol), which is suitable to long-distance and complex data transmission (e.g. patient-surveillance or chemical detection in agriculture), and for fixed sensor nodes of WSN. PECRP combines the advantages of some excellent cluster-based routing protocols together, such as HEED (Hybrid Energy-efficient Distributed Clustering Approach), PEGASIS (Power-Efficient Gathering in Sensor Information Systems) and so on.

The work in paper [23], focuses its research on the integration of existing computer tools in order to establish an application development environment for WSN, uniting the robustness of programming languages with the usability of a friendly interface.

The paper [24] presents two applications of WSN supported by the IEEE 802.15.4 protocol; the first one is oriented to monitoring a mushroom crop and the other one to e-health. Both applications are monitoring-oriented, results obtained show how WSN can be used to support requirements of applications for data acquisition in distributed and collaborative way.

The paper [25], proposed a system where hybrid hexagonal positioning for sensor node has achieved better link utilization compare to other topology saving energy and increasing life lime of sensor node and network. A village centric model is presented to define applicability of proposed solution.

In paper [26], in order to study how current irrigation practices affect the environment, the researchers build and deploy a WSN in a sugar farm. The system acquires data from the sensor network in the field and transmits the data through microwave link to back-end server.

In paper [27], a self-organizing ad-hoc sensor network is deployed in vineyard, which collects the temperature data throughout the vineyard. Based on the temperature data, the back-end application calculates and shows a map of powdery mildew risk to help the vineyard management.

IV. Classification of Existing Systems

The existing system studied so far may be classified in two categories. These are a) simulator based and b) implementation based.

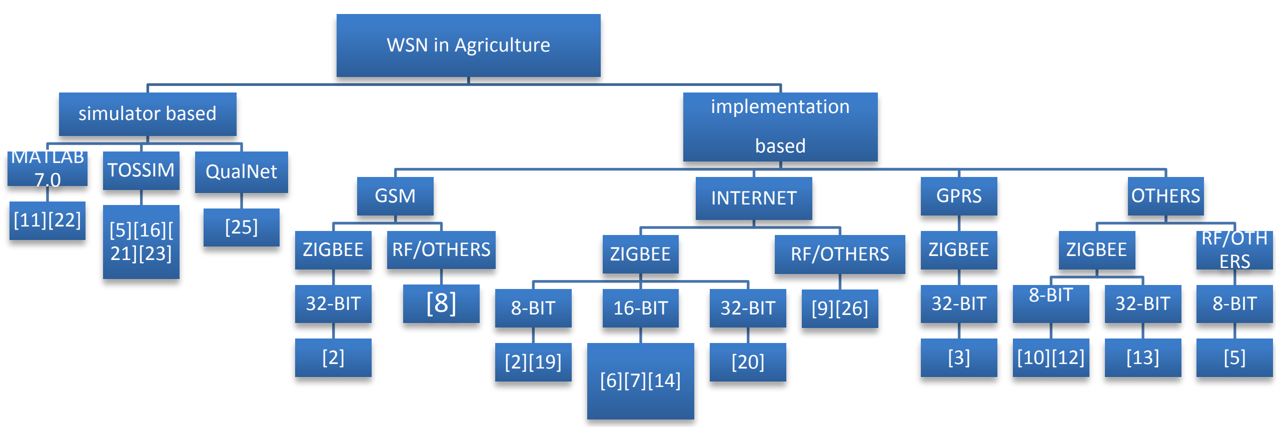


Figure 1 : Classification of Existing Systems

The proposed system in [5] [11] [15][16] [21] [22] [23] [25] are simulator based. The simulator used to conduct an experiment in [11] [22] is Matlab 7.0 and in [5][16][21][23] TOSSIM is used, whereas in [25] Qual Net simulator is used.

The energy efficient WSN for agriculture proposed in [5] compares the performance of PDMAC with SMAC, the behaviour of two nodes, a sender and a receiver was simulated using TOSSIM.

In [11], Xihai Zhang, Yachun Wu and Xiaoli Wei evaluated the performance of NMDS-RSSI localization algorithm, using data from the farm and concluded that the average value of localization error decreased with the increase of signal propagation coefficient and the simulation results shows that the NMDS-RSSI localization algorithm yield better performance than the MDS-MAP in same simulation conditions.

In [21] XIONG Shu-ming, WANG Liang-min, QU Xiao-qian, ZHAN Yong-zhao proposed a cluster based multi-hop routing to reduce energy consumption of node transmitting data. Simulation results show that the application is correct and reasonable and enables user to precisely acquire the crop water requirement information.

In [22] Tao Liu, Feng Li also proposed a new type of routing protocol for WSN called PECRP (Power-efficient Clustering Routing Protocol), and simulation results show that PECRP has better performances than LEACH in prolonging lifetime and transmitting data in the symmetrical distribution of nodes in WSN.

In [23] Gracon H. E. L. de Lima, Lenardo C. e Silva, Pedro F. R. Neto M proposed the integration of existing computer tools in order to establish an application development environment for WSN, uniting the robustness of programming languages with the Usability of a friendly interface.

In [25] milind pande, N.K. choudhari, shantanu pathak and debajyoti mukho padhyay shows that the hybrid hexagonal positioning(HHP) for sensor nodes has achieved better link utilization compared to other technology saving energy and increasing the lifetime of sensor node and network.

The system proposed in [2][3][5][6][7]-[8][9][10][12][13][14][15][16][19][20] are designed, implemented and real-deployed. Now these systems can further classified on the factors like technology used, processor used, sensor used, monitoring devices and crops monitored. This classification is shown in the given table:

Table 1 : Classification of Existing Remote Monitoring and Control Systems

References	Technology	Monitoring System	Module Interfaced	Processor used	Sensor Interfaced
[2]	Zigbee, internet	Laptop	-	89c52	Moisture sensor
[3]	Zigbee, GPRS	Mobile	JN5121	ARM9	Soil moisture/ temperature
[5]	RF	LCD	CC1110	8051	-
[6],[7]	Zigbee, internet	Laptop, pda	CC2420	MSP430	Temperature/ humidity/ illumination
[8]	GSM, RFID	-	-	-	Camera nodes, cattle sensor network, soil moisture.
[9]	RF, internet	Laptop, PDA	C43271	C43271 Psoc	TOUCH, TEMPERATURE, moisture, LIGHT
[10]	Single sensor node	-	-	89C52	Temperature/ humidity / ph
[12]	zigbee	PC	nRF905	89C51	Temperature/ humidity
[13]	Zigbee	TFT-LCD	nRF905	MCF52235	Temperature/ humidity
[14]	Zigbee, Internet	PC	Zigbee module 3160	SPCE061A	Temperature/ humidity/soil temperature/ soil moisture/co2/ illumination
[16]	Zigbee, internet	Laptop, pda	MSENS SoC		Air Temperature/ humidity/soil temperature/ soil moisture/ anemometer /radiometer /rain gauge/ CMOS image
[19]	Zigbee, internet	PDA	Zigbee transreceiver	8-Bit MCU	Light/ temperature / humidity
[20]	Zigbee, internet	PDA	JN5121 with On chip 32 bit core		Light/ temperature / humidity/ wind speed
[26]	wired ADSL, internet	NRF905	PC	Atmega-128	-

The above research papers studied so far, demonstrate the effective use of WSN in agriculture. However, most of the papers have proposed various schemes to make this system effective and efficient but those schemes are not deployed in real field and the papers where real field deployment is done, that is not suitable for all the crops. As we know that every crop has different requirement, so it is necessary to design and implement a system by taking the requirement of particular crop into account. In [26] the system is designed and deployed for sugarcane field but that may not be suitable in the Indian environmental conditions for sugarcane.

V. Proposed Work

India is the world's largest producer of sugarcane. Of the several agricultural crops, sugarcane is most remunerative crop and has a very high economy biomass to total biomass ratio. Its requirement for water and fertilizer are equally high. Sugarcane roots may extends to 90cm depth and grows extremely well in medium to heavy, well drained, soil of pH 7.5 to 8.5 and high organic matter content.

Heat, humidity and sunlight plays important role in sugarcane germination, tillering, vegetative growth and maturity. Sugarcane grows well in humid and hot weather it require humidity of 70% for more vegetative growth.

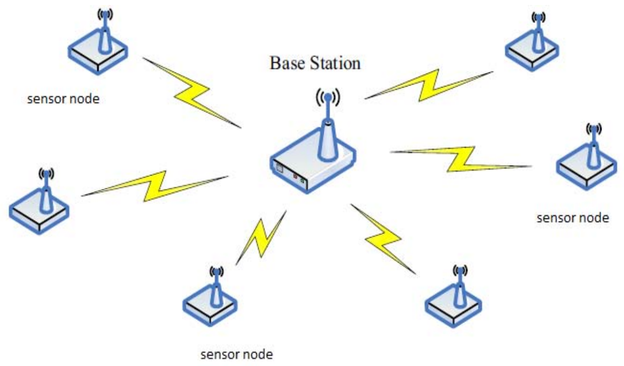
Table 2 : Effect of climatic factors on sugarcane [28]

	Air temperature	Soil temperature	Soil moisture	Humidity
Sprouting	Optimum 26-33deg .C. Minimum-18degC	Optimum 23-28deg .C. Minimum-19degC	Initiated by water	-
Tillering	Assisted by cool nights	Less if soil is warm	Helped by sufficient moisture in soil	-
Growth	Optimum at 30-33degC, poor<20degC	Optimum 23-29deg .C. Poor<21degC	Adequate moisture essential	Better in humid air
Flowering	Warm nights helps, halted by few nights at 18degC	Maximum in warm soil	Optimum in moist soil, halted by drought	Some humidity is required
Ripening	Prompted by cold nights, optimum<15degC	Best at low temperature	Prompted by lack of moisture	Better in very dry climate
Over ripening	Prompted by return of hot season	Helped by increase in temperature	Prompted by water being available after a dry period.	-

According to the above information, it is clear that growth of sugar cane crop is highly dependent on few climatic factors like air temperature, humidity, and soil temperature and soil moisture. So it is essential to monitor few climatic conditions for the better yield of sugarcane.

This paper would take the opportunity to design an instrument that is able to monitor the ait temperature, humidity, and soil temperature and air moisture of an agricultural field and transmit it to a remote receiver outside the field. The system represented in this paper is composed of the microcontroller, WSN base station with GSM module, Data collecting nodes, device control node and mobile phone. The WSN data collecting node is connected with temperature, soil moisture and humidity sensor. When these sensor nodes find an abnormal or unsuitable environment condition of the soil the nodes will send encoded alarm signal to base station. Once the base station receives an alarm signal, it will send a SMS to farmer through the GSM module and GSM network immediately.

Figure 2 : Structure of Wireless Sensor Network



a) Sensor node design

The sensor node is the basic unit of the environmental information monitoring system; its task is to achieve the perception, collection, processing and wireless communication of environmental data.

The general architecture of a wireless sensor node is presented in Fig. 2. As seen from the figure, a wireless sensor node is composed of four major components which are namely, the sensing unit, the processing unit, the power unit and finally the wireless transceiver unit. The sensing unit converts such measured physical quantities as temperature, moisture etc. into a voltage signal and digitizes it to produce digital output for processing. The processing unit with a microcontroller controls all of the functions of the sensor node and manages the communication protocols to carry out specific tasks. Communication between the WSN node and the base station is provided by the transceiver unit. And finally the power unit, which is the most crucial component of a sensor node, supplies mandatory power to all of these units.

b) Base station unit

This unit is responsible for collection of the data from all the sensor nodes and critically evaluate the data, if it finds an abnormal or unsuitable environment condition of the soil, the base station send a SMS to farmer through the GSM module and GSM network immediately.

VI. Conclusion

The proposed system in this paper is designed by considering the requirement of a sugarcane crop for Indian climatic conditions. The WSN in agriculture is new technology for information acquisition and processing in sugarcane field. It is more advantageous than the traditional agriculture techniques. This work structured the precision agriculture monitoring system by wireless sensor nodes and base station to record the data of sensor nodes. This is low cost system where the recorded information is transmitted to remote location using a GSM network via a SMS. The farmer may use the received information to control the parameters. This kind of wireless detection and control improves the effectiveness and efficiency of resources used, which leads to the improved production. The drawback of system is its dependency on the GSM network.

VII. Future Work

The other problem farmers are facing is the crop destruction by the wild animals. So the future work include the design of the system that may monitor the farm by installing sensors at the boundary of farm and a camera module which may take a snapshot once the sensor detects the entrance and transmit the real time pictures by integrating it with other information.

References Références Referencias

1. Kshitij shinghal, Dr. Arti noor, Dr. Neelam srivastava, Dr. Raghuvir singh, wireless sensor networks in agriculture: for potato farming.
2. Prakash gaud patil, vidya h2, shreedevi patil, umakant kulkarni, wireless sensor network for precision agriculture, 2011.
3. Jianfa Xia, Zhenzhou Tang, *Xiaoqiu Shi, Lei Fan, Huaizhong Li, An environment monitoring system for precise agriculture based on wireless sensor networks, 2011.
4. A Survey on Zigbee Based Wireless Sensor Networks in Agriculture T. Kalaivani, A. Allirani, P. Priya, 2011 IEEE.
5. Herman Sahota Ratnesh Kumar Ahmed Kamal Jing Huang, an Energy-efficient Wireless Sensor Network for Precision Agriculture, 2010 IEEE.
6. Ying Zhang, Design of the node system of wireless sensor network and its application in digital agriculture, 2011 IEEE.
7. Lei Xiao, Lejiang guo, The Realization of Precision Agriculture Monitoring System Based on Wireless Sensor Network, 2010 IEEE.
8. Tim Wark, Peter Corke, Pavan Sikka, Lasse Klingbeil, Ying Guo, Chris Crossman, Phil Valencia, Dave Swain, and Greg Bishop-Hurley, Transforming Agriculture through Pervasive Wireless Sensor Networks, 2007 IEEE.
9. D.D. Chaudhary, S.P. Nayse, L.M. Waghmare, application of wireless sensor network for greenhouse parameter control in precision agriculture. 2011 IJWMN.
10. Application of Wireless Sensor Networks For Agriculture Parameters, Awati J.S.1, Patil V.S.2 And Awati S.B, International Journal of Agriculture Sciences Issue 3, 2012, PP-213-215.
11. Localization algorithms in wireless sensor networks using Non metric Multidimensional scaling with RSSI for precision agriculture, Xihai Zhang, Yachun Wu, Xiaoli Wei, 2010 IEEE.
12. Research of Temperature and Humidity Monitoring System Based on WSN and Fuzzy Control Xinrong Zhang, Bo Chang, 2011 IEEE.
13. A Low-Power Temperature and Humidity Monitoring System Base on Wsn J.J. LI, F. WANG*, 2011.
14. A Monitoring System Based on Wireless Sensor Network and a SoC Platform in Precision Agriculture, Jzau-Sheng Lin, Chun-Zu Liu, 2008 IEEE.
15. Design, Fabrication and Testing of Fringing Electric Field Soil Moisture Sensor for Wireless Precision.
16. Agriculture Applications S. Sulaiman, A. Manut and A.R. Nur Firdaus, 2009 IEEE.
17. Design of Wireless Multi-media Sensor Network for Precision Agriculture YIN Shouyi1, 2, LIU Leibo1, 2, ZHOU Renyan1, 2, SUN Zhongfu3, WEI Shaojun, 2013.
18. A Review of Wireless Sensor Technologies and Applications in Agriculture and Food Industry: State of the Art and Current Trends Luis Ruiz-Garcia 1,*, Loredana Lunadei 1, Pilar Barreiro 1 and Jose Ignacio Robla, 2009.
19. Wireless sensor networks: a survey I.F. Akyildiz, W. Su*, Y. Sankara subramaniam, E. Cayirci, 2002.
20. A2S: Automated Agriculture System based on WSN Seong-eun Yoo, Jae-eon Kim, Taehong Kim, Sungjin Ahn, Longwood Sung, Daylong Kim, 2006.
21. Study on Precision Agriculture Monitoring Framework Based on WSN Xuemei Li, Yuyan Deng, Lixing Ding.
22. Application Research of WSN in Precise Agriculture Irrigation XIONG Shu-ming, WANG Liang-min, QU Xiao-qian, WANG Liang-min, 2009 IEEE.
23. Power-efficient Clustering Routing Protocol Based on Applications in Wireless Sensor Network Tao Liu, Feng Li, 2009 IEEE.
24. WSN as a Tool for Supporting Agriculture in the Precision Irrigation Garcon H. E. L. de Lima, Leonardo C. e Silva, Pedro F. R. Neto, 2010 IEEE.
25. Applications of WSN in Health and Agriculture Andrés F. Murillo, Mauricio Pena, Diego Martinez, 2012, IEEE.
26. H2E2: A Hybrid, Hexagonal & Energy Efficient WSN Green Platform for Precision Agriculture, Milind pande, N.K. choudhari, shantung pathak and debajyoti mukho pathway, 2012 IEEE. [26] Outdoor Sensornet Design and Deployment: Experiences from a Sugar Farm, Wen Hu, Tuan Dinh Le, Peter Corke, sanjay jha, 2012 IEEE.
27. Vineyard Computing: Sensor Networks in Agricultural Production, Jenna Burrell, Tim Brooke, and Richard Beckwith, 2004, IEEE.
28. Modern Irrigation & Fustigation Methodology for Higher Yields in Sugarcane by Jain.Com.
29. Xbee pro data sheet: ftp: //ftp1.digi. com/support/Documentation/90000976_C.pdf.