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Agricultural Environmental Monitoring: A WSN Perspective.

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Abstract: In this article, we develop a system based on WSN platform to measure the data of crop parameters for the agriculturists aimed to enhance the quality and quality of the crops. The proposed system will minimize the exhaustive field visits of the farmers. This system will facilitate the precision agriculture by measuring three most key parameters (temperature, humidity and light) of the crops. The proposed system consists of IRIS motes MDA100CB data board, and MIB520 USB interface board. These are considered as sink and sensor nodes respectively. TinyOS is used to develop the code for WSN nodes, and GUI device is composed in Microsoft Visual Studio-2008 for displaying the measured data and stored in data base accordingly. ZigBee IEEE 802.15.4 and direct topology are utilized for the correspondence of sensor nodes with the base station.

Keywords: Wireless Sensor Network, Agricultural Environmental Monitoring,Data Acquisition, TinyOS

I. INTRODUCTION

Modern agriculture system needs electronic devices and technologies that can improve the production efficiency, production quality, post-harvest processes, and would be able to reduce environmental impacts. Automation in agriculture has brought about a fundamental role to what is now known as smart agriculture [7] (also known as precision agriculture) [1, 2]. Agriculture is the cultivation of animals as well as humans, although plants and other life forms for food and to make them source, fiber, biofuel, apart from that medical and other products used to put up and to enlarge human life [1]. The main source of livelihood of mankind is agriculture. Agriculture plays vital and crucial role in developing countries including Pakistan; it provides large scale employment to the people. However, agriculture is highly dependent on climate and weather. For instance, change in humidity, temperature and carbon dioxide may result in low yield of cash crops. The most important cash crops are cotton, wheat, sugar-cane, etc. [8]. So, it is significant to monitor environmental parameters in order to manage crop growth and improve the production, and latest technology is being implemented in agriculture to save time, use of fertilizers, use of pesticides, to condense human struggles, to decrease the expenses in cultivation of the crops.

Wireless sensor networks are quickly gaining popularity [8] due to the fact that they are potentially low-cost solutions to a variety of real-world challenges [12] and troubles. The wireless sensor networks have been utilized in number of real time applications. WSN is a system which is comprised of sensors, radio frequency (RF) transceivers, microcontrollers, power sources and base station. Wireless Sensor network can be possibly employed in different fields such as environmental monitoring, high ways, buildings/structures watch out, military surveillance, and industrial and manufacturing automation in factories [1], [2], electronic commerce, indoor climate control, military surveillance, intelligent alarms, habitant monitoring, patient monitoring, agriculture sector and irrigation [9], [10]. For agriculture wireless sensor networks can help for monitoring the fields and crops, thus sensor networks are helping farmers to prevent damages to their crops and increasing crop yield. Wireless sensor networks can be used specially in agriculture sector to display key parameters of the certain crops; hence in crops cultivation these can help farmers [3]. WSNs handling such a wide range of applications also share a set of characteristic requirements which majorly include lifetime, real time, fault tolerance, scalability, programmability, maintainability, security, production cost & QoS [3].

In this paper Mushtaque Ahmed Rahu[1] contributed in data collection, manuscript writing, statistical analysis, and interpretation of results. Dr. Pardeep Kumar[2] contributed in proposed topic, study design and methodology. Sarang Karim[3] contributed in Literature review, referencing, quality insurer, discussions. Azeem Ayaz Meerani[4] contribution is technical support.

II. SYSTEM OVERVIEW

Main System block diagram is given in Figure 1. The proposed system contains different devices i.e. IRIS motes; a sink node and three sensor nodes, sensors; temperature-Humidity and LDR and display device. The medium used is Wireless medium used for Sink and sensor nodes and for communication direct topology has been used. With sensor board sensors are attached which are in contact with IRIS motes. The data is sensed through sensors and same data is transferred to base station by sensor nodes, where sink node receives the data with the help of MIB520CB programmable board, serially sink node is connected with computer via USB (Universal Serial Bus) port. End user can see the data on a GUI tool without any difficulty.

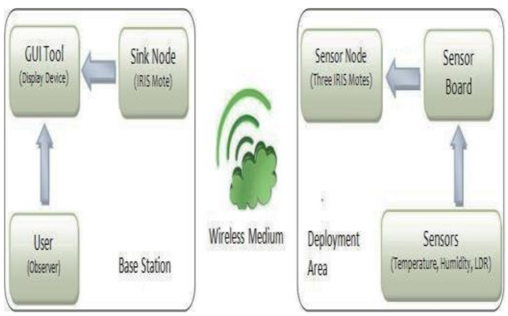


Figure 1: System block diagram

III. MOTIVATION

Meanwhile farmers are incapable to gaze the entire field and protecting it from risky (rain and floods etc.) environmental conditions, soil moisture, watering, observing the level of water of entire crops in malicious time. Farmers cannot achieve all the goals and also to have looking at the field to defend it from seed eating birds. So, for accomplishing these responsibilities easily, quickly and consequently Electronic Devices are required. We can sense possibility occurrence of the unwanted situations, environmental unwanted situations including Temperature, Humidity, Light, etc. by wireless sensor networks. Observing of these farm duties is not possible for menfolk. Therefore, usage of sensor networks would condense farmers time and efforts.

IV. SCOPE OF WORK

Enlisted below is the Scope of the work.

- Recognition of unwanted environmental situations
- Reduce agriculturalists energies and period
- Observing of crops: through database on Regular basis
- Finally, budget/harvest decreased and profit/harvest improved.

V. RELATED WORK

The huge number of research work has been conducted in the past relating to the field of wireless sensor network and it's characteristic. The sensor network has been utilized in the number of real time applications.

Shivaraj, B., and Natarj Urs U.D., (2015) [3] presented a summary review on few selected WSNs implementation architectures which have been used for environmental monitoring and summarized and contrast selected WSN implementations under different headings highlighting the advantages and disadvantages.

Korake, P.M. and Bhanarkar, M.K. (2015) [6] presented an anticipated system, optimization of temperature and humidity measurement WSN node usingATmega328 for grapes environmental conditions checking, lot of systems are facilitated in the market which are based on Wireless sensor network (WSN) but this method is portable, small size and more energy capable. Sensor is integrated package contains temperature and humidity measurement capability in one package.

Kumar, K.A, et al. (2014) [10] have toiled on fluoride affected area remote monitoring system using GIS, GPS, then GPRS systems. This design enables users to access the status of fluoride sensor at remote station on their cell phones via Internet. Government organizations and ordinary people can also make use of this system to monitor affected areas of fluoride.

Devadas, R., et al (2010) [27] have made an instrumentation setup for monitoring the water and Nitrogen of wheat crops. They have developed WSN based system for collecting shadowy data crucial in 7 constricted-mobs (470, 550, 670, 700, 720, 750, 790 nm) on behalf of yield progress surveillance on distinct spatial sampling approaches. Spectral data measured in intervals up to 30 seconds were transmitted at field site base station via wireless multi-hop network. Moreover, these data were dispatched at remote station via broad-band internet access. Authors have compared the results obtained from sensor network with the industry based spectral radiometer and found some differences in spectral measurements for 790nm while for all other bands no any difference were found.

VI. SYSTEM DESIGN

A. System Architecture

The whole system physical view is shown in Figure 2. There are three source motes; at base station direct topology is used with a sink node. Sensor motes have been deployed in cultivating area away from each other on three different locations. The arrangement of these sensor motes with three sensors, LDR and Temperature-Humidity sensor for computing the data of yields is given. Architecture system directs about the hardware which elaborates in monitoring of precision agriculture. A Personal Computer at base station is for showing results and for maintaining records in database of measured data of field and post processing. The batteries are used as a power source for sensor nodes.

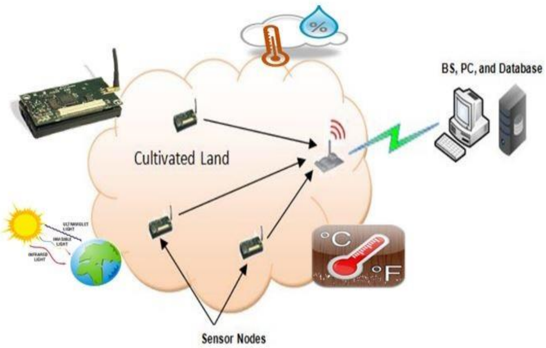


Figure 2: Architecture of system and physical view

B. Deployment of Prototype System

At Qazi Ahmed city crop fields and the surrounding rural areas the experimental work and real time deployment of sensor nodes carried out. The distance between surrounding rural area is far from each other. As shown in Figures 3a & 3b. At the time of experimental work sink is placed at approximately 10 meter far from its adjacent source mote & remaining two source motes existed little far from the sink node. About 60 minutes the experimental work carried out in morning, afternoon and evening. Approximately Four weeks to collect the results from the resultant motes. Apart from temperature-Humidity and LDR measurement were also measured.

(a) Sink node & three sensor nodes

(b) Three sensor nodes

Figure 3: Deployment of prototype system

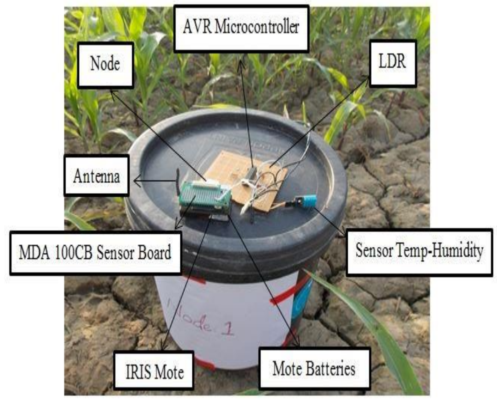


Figure 4: Complete portrait of sensor node

C. Sensor Node

We have used IRIS motes for the experimental work. In TinyOS it is duly programmable Environment. The complete portrait of a sensor node is shown in Figure 4. Various devices are equipped in sensor node i.e. Microcontroller Board, MDA100CB Board and (Temperature, Humidity and LDR) Sensors.

VII. SYSTEM METHODOLOGY

To reduce the huge efforts & energies of farmers the scenario and delivered some practices to increase the quality production of yields have been deliberated. The applied inputs by farmers such that fertilizers, pesticides, water, etc. at proper time and proper quantity and obviously, there will be increase of production slightly. In this system, a code has been developed. This is wireless sensor network Designed based, data sensed by sensors then that data communicated by a radio transmitter to the base station, wherefrom essential directions have been adopted. On a GUI display tool the data is exposed, and can be kept that data into database. In Figure 5 the research methodology flowchart. List of Devices Used in the Proposed System: In the planned system following devices have been used:

- Programmable USB Interface Board MIB520CB [31]
- Data Acquisition Board/ Sensor Board MDA100CB [33]
- IRIS Mote XM2110CA, 2.4 GHz [32]
- Sensors (Temperature-Humidity, LDR Sensor) [34]
- Microcontroller Atmeag8 [30]
- Active and Passive Components (Diodes, RLC, etc.)

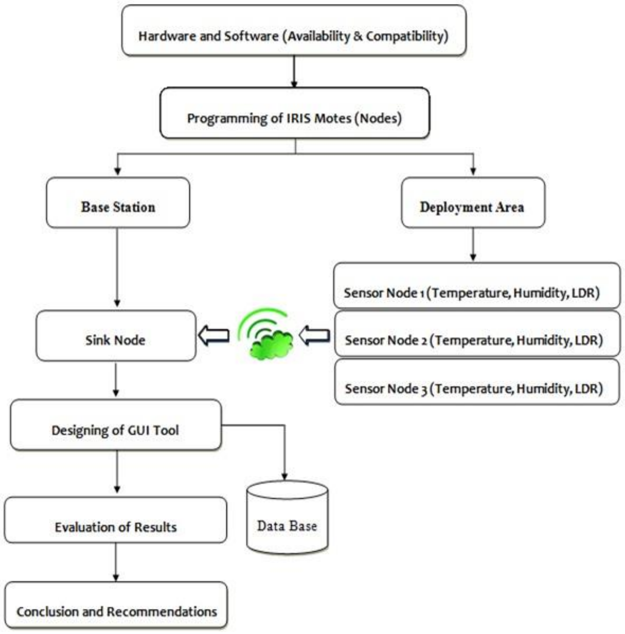


Figure 5: Research methodology

VIII. DISPLAY TOOLS

A. GUI Tool

As in Figure 6, in Visual Studio 2008 main GUI tool is intended for detecting the received data from dissimilar three Sensor nodes. Every node consists of three sensors; LDR & Temperature-Humidity sensor. Three nodes in Figure 6 are shown. For connecting the GUI tool with MIB520 programmable board connect button is given and is accordingly connected to (Sink Node) IRIS Mote through serial communication with PC. From these three source nodes Sink IRIS mote receives data. For displaying the source nodes sent data display data log button is used. Each node data can be perceived instantaneously and independently in data log window.

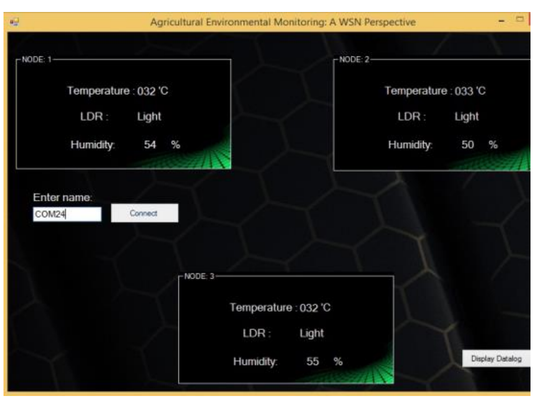
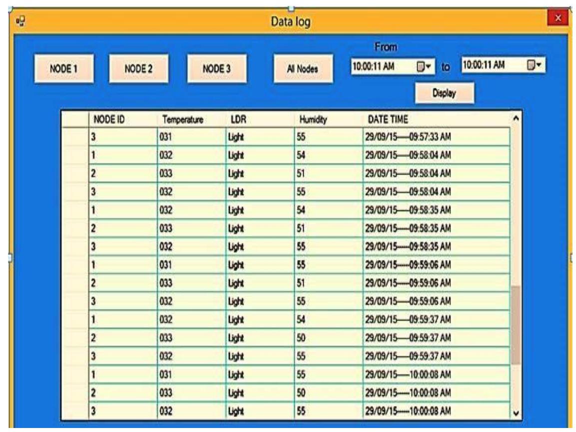


Figure 6: Main GUI tool

B. Data log Window

The data transmitted by the source nodes is described in data log window as shown in above given Figure 7, that data is fed directly into database file in Microsoft Access format. We can observe the data of each node in this data log having parameters; temperature, humidity and LDR with time and date. The features of Data log are it shows the data of every node independently and merged. As mentioned in the Figure: 7 Data of the nodes of specific date and time can also access by pressing the Display Button.



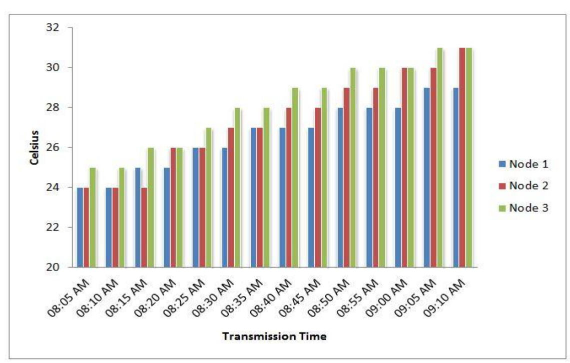
NODE ID	Temperature	LDR	Humidity	DATE TIME
3	031	Light	55	29/09/15—09:57:33 AM
1	032	Light	54	29/09/15—09:58:04 AM
2	033	Light	51	29/09/15—09:58:04 AM
3	032	Light	55	29/09/15—09:58:04 AM
1	032	Light	54	29/09/15—09:58:35 AM
2	033	Light	51	29/09/15—09:58:35 AM
3	032	Light	55	29/09/15—09:58:35 AM
1	031	Light	55	29/09/15—09:59:06 AM
2	033	Light	51	29/09/15—09:59:06 AM
3	032	Light	55	29/09/15—09:59:06 AM
1	032	Light	54	29/09/15—09:59:37 AM
2	033	Light	50	29/09/15—09:59:37 AM
3	032	Light	55	29/09/15—09:59:37 AM
1	031	Light	55	29/09/15—10:00:08 AM
2	033	Light	50	29/09/15—10:00:08 AM
3	032	Light	55	29/09/15—10:00:08 AM

Figure 7: Datalog window for nodes data

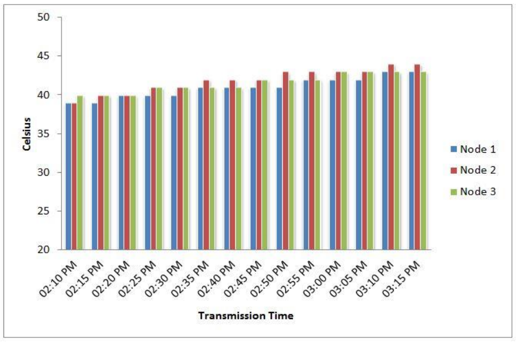
IX. RESULTS AND DISCUSSIONS

A. Temperature Measurement

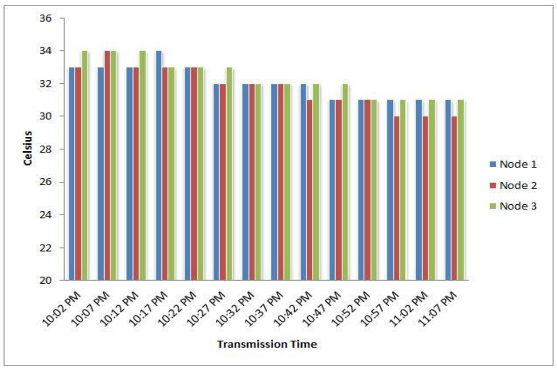
Temperature measurements of all three nodes at different transmission time and session (morning, afternoon and night) as in Figure 8. The graphs given below are showing temperature (in Celsius) w.r.t transmission time measured by Node 1, Node 2 and Node 3. From following graphs, it is clearly acknowledged that the average measurements of all three nodes are in equalization. Well, the minor differences are come in cross due to variation in atmospheric pressure, line of sight, calibration of devices, interference of signals, power consumption, and the distance between sink and sensor nodes.



(a) Measurement of sensor nodes (1,2 and 3) during morning



(b) Measurements of sensor nodes (1, 2, and 3) during noon

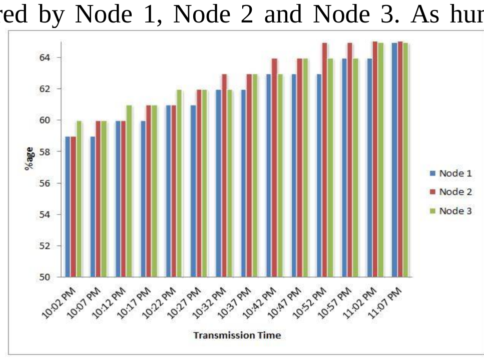


(c) Measurements of sensor nodes (1, 2, and 3) during night

Figure 8: Temperature measurements

B. Humidity Measurement

Humidity measurements of all three nodes at different transmission time and session (morning, afternoon and night) as in Figure 9. The graphs given below are showing humidity (in %age) with respect to transmission time measured by Node 1, Node 2 and Node 3. As humidity is

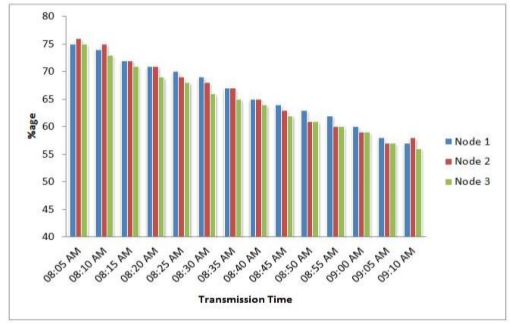


(c) Measurements of sensor nodes (1, 2, and 3) during night

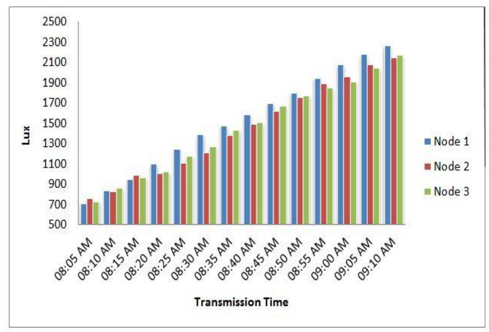
C. LDR Measurement

LDR measurements of all three nodes at different transmission time and session (morning, afternoon and night) as in Figure 10. The graphs given below are showing light intensity (in Lux) with respect to transmission time measured by Node 1, Node 2, and Node 3. Following

indirect relation temperature, consequently humidity will be increased as temperature is increased. By comparing above temperature graphs in Figure 8 with humidity graphs in Figure 9, it justifies the above statement. During morning time humidity is low as the time passed and the temperature and sun light are increased accordingly, the humidity is also increased.



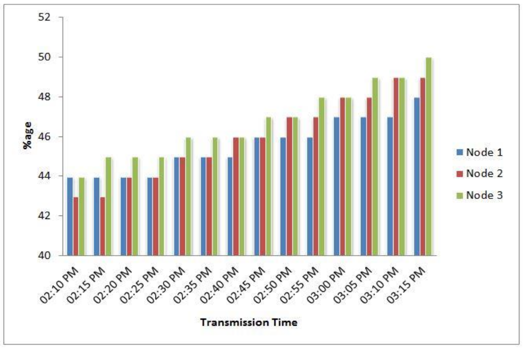
(a) Measurements of sensor nodes (1, 2, and 3) during morning



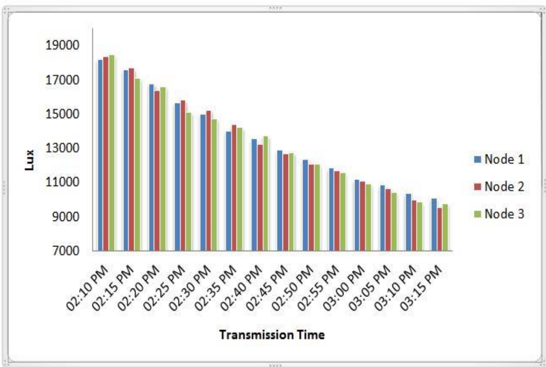
(b) Measurements of sensor nodes (1, 2, and 3) during noon

Figure. 9: Humidity measurements

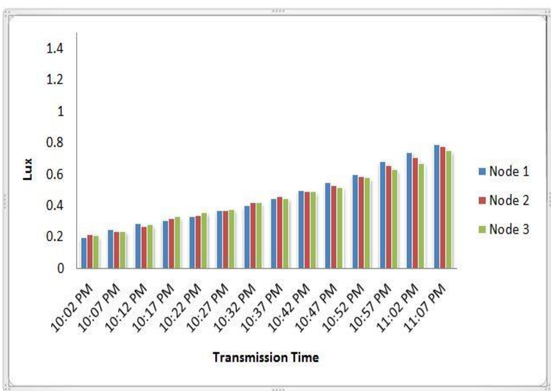
graphs are for the detection of sun light. As we know that the sun plays a pivotal role and contains a significant consideration in agriculture sector, because the crops prepare the food from the sun light. Also, the length and growth of the crops are liable to sun light. The determined graphs are showing different states of the sun light. The intensity Lux is indirect relation with sun light, as sun light increases the value of Lux also increases and vice versa. While, during night, it can be observed that the values of Lux are almost in level at different states of transmission time. The variation has been occurred at late night due to moon light.



(a) Measurements of sensor nodes (1, 2, and 3) during morning



(b) Measurements of sensor nodes (1, 2, and 3) during noon



(c) Measurements of sensor nodes (1, 2, and 3) during night

Figure 10: LDR measurements

X. CONCLUSIONS

The System arrangement is based on practice wireless data acquisition system of field harvests through Wireless Sensor Networks. This offers the solutions to many difficulties challenged by farmers at crops. Performance of IRIS motes real time deployment has been shown. IRIS motes remained appropriately programmed to get the (temperature, humidity and light intensity) data of crops & to transmit that observed data to the BS through medium of wireless. So, this work is about WSNs deployment in different crop fields. So, the objective is attained and these results after the implementation of this system have been evaluated. Firstly, analyzing of temperature-Humidity and LDR parameters. GUI tool helped in showing results comprehensible and clear. Every user can understand the results easily without concerning any research expert. Database is used to maintain up to date information about collected data by the sensor node. In last, inter-node distance either increase or decrease the data delivery rate of the sensor nodes. So, for required parameters measuring the (temperature, humidity and light intensity) of the field to its BS this project provides ease to the users, every time they are not required to visit at crops, however just deployment of motes ones & acquire the measured information at room, BS, at the office, etc. Thus, available platforms, major deployment areas and the architecture of a WSN have been conferred. Diverse techniques and methods have been declared, concerning data transfer towards precision agriculture.

XI. RECOMMENDATIONS

This work is about WSN system based on recommendations of crops according to suitable area as per environmental conditions (i.e. mud, water, temperature etc.) and instructions have been provided for crops to the growth according to environmental conditions. The data is continuously monitored at base station; detail of crops is given in above table Figure 11 and Map Figure 12.

Sr.#	Crop	Requirements of the Crops: Temperature (ADAPTATION)	Humidity (ADAPTATION)	watering	Length	Suitable area for cultivation
1	Cotton	26 to 30 °C	50 to 80 %	7 to 8 irrigations	170 to 190 days	A1
2	Wheat	21 to 24 °C	53 to 60 %	6 to 7 irrigations	110 to 130 days	A2
3	Rice	Above 30 °C	71 to 80 %	04 to 05 irrigations	150 to 180 days	A3
4	Maize	20 to 22 °C	30 to 50 %	05 to 06 irrigations	60 to 65 days	A4
5	Sugarcane	19 to 30 °C	60 to 80%	20 to 24 irrigations	10+ to 12+ months	A5

Figure 11: Recommendations about crop suitable area as per environmental conditions

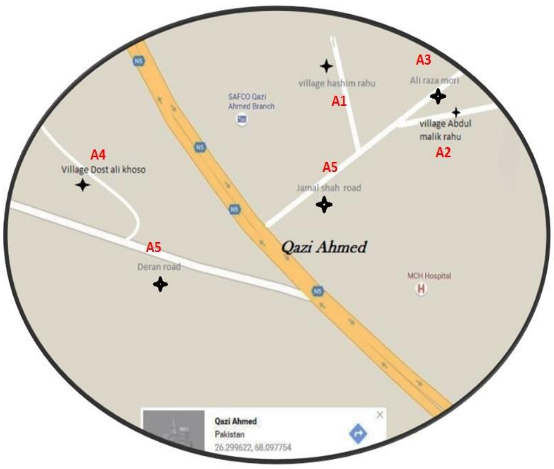


Figure 12: Crops suitable area map as per environmental conditions

XII. Future Work

This is the moment that states which is leading technology in agriculture and is appropriate for certain & surrounded applications as. It is seen that the machinery, methods techniques and actuality used in deployment setups do not linked to only field or technology however, combinations, different technologies and group of many fields altogether remain linked. So, an abundant sympathy is constructing to use of wireless sensor networks, for its enhanced latent & consequence. Numerous equipment has been used widely for precision agriculture as last few decades. Hence system can be used in large areas, multiple nodes can be used and multi hoping can be used. Simultaneously by applying one or more than one following areas this work can be enriched.

XIII. Acknowledgements

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XIV. References

[1] Singh, B and Harender, D. (2015), Intelligent Monitoring & Controlling of Agricultural Field Parameters Using Zigbee, International Journal in IT and Engineering, ISSN: 2321-1776, Vol.03 Issue-01.

[2] Chaudhari, M.S, Jaiswal, R, Birade, C. and Bhapkar, V. (2015), Wireless Sensor Network as a Tool for Supporting Agriculture in the Precision Irrigation System International Journal of Advanced Research in Computer and Communication Engineering Vol. 4, Issue 2.

[3] Shivaraj, B., and Natarj Urs U.D., (2015), Wireless Sensor Networks for Environmental Monitoring: A Theoretical Review Journal of electronics and computer science, ISSN- 3967-0867.

[4] Zhang, Z., Yu, X., Wu, P. and Han, W. (2015), Survey on Water-saving Agricultural Internet of Things based on Wireless Sensor Network International Journal of Control and Automation Vol. 8, No. 4, pp. 229-240.

[5] M Monisha, TG Dhanalakshmi. (2015), A Review on Precision Agriculture and Its Farming Methods Research Journal of Pharmaceutical, Biological and Chemical Sciences, RJPBCS 6(3), ISSN: 0975-8585, Page No. 1142.

[6] Korake, PM and Bhanarkar, MK. (2015), Humidity and Temperature Measurement WSN node for Grapes Environmental Condition Monitoring European Journal of Advances in Engineering and Technology, ISSN: 2394 - 658X, 2(5): page No/72-76.

[7] Lachure, S, Bhagat, A and Lachure, J. (2015), Review on Precision Agriculture using Wireless Sensor Network International Journal of Applied Engineering Research, ISSN 0973-4562 Vol. 10 No.20.

[8] Bansode, S, Raut, C, Meshram, P and V.R, P. (2015), An Automatic Identification of Agriculture Pest Insects and Pesticide Controlling International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE), ISSN 2349-7815 , Vol. 2, Issue 2, pp:21-28.

[9] Xu, G, Shen, W and Wang, X. (2014), Applications of Wireless Sensor Networks in Marine Environment Monitoring: A Survey ISSN 1424-8220.

[10] Kumar, K.A, Lingam, P.G and Rao, K.M. (2014), Wireless Sensor Based Remote Monitoring System For Fluoride Affected Areas Using GPRS and GIS, International Journal of Computer and Technology (IJCTT) volume 7 number 4, ISSN: 2231-2803, pp: 178-182.

[11] Chaitanya, N.K, Kumar, G.A and Kumari, P.A. (2013), Zigbee based Wireless Sensing Platform for Monitoring Agriculture Environment International Journal of Computer Applications (0975 8887), Volume 83 No.11.

[12] Mishra, D.P and Kumar, R. (2013), Wireless sensor network design for paddy Crop monitoring of chhattisgarh International Journal of Advanced Engineering Research and Studies, E-ISSN22498974, 107-111.

[13] Satyanarayana, G.V and Mazaruddin, SD. (2013), Wireless Sensor Based Remote Monitoring System for Agriculture Using ZigBee and GPS, Conference On Advances in Communication and Control Systems (CAC2S 2013) pp: 110-114.

[14] Vijayalakshmi, A and Ranjan, P.V. (2013), Code Strategy Algorithm For Online Power Quality Monitoring Of Electrical Equipment Using WSN Under Tiny-Os Environment, Journal of Theoretical and Applied Information Technology, Vol. 57 No.3, pp:465-473.

[15] Awasthi, A and Reddy, S.R.N. (2013), Monitoring for Precision Agriculture Using Wireless Sensor Network-A Review, Global Journal of Computer Science and Technology Network, Web & Security Volume 13 Issue 7 Version 1.0.

[16] YU, X, WU, P, Wang, N, Han, W and Zhang, Z. (2012), Survey on Wireless Sensor Networks Agricultural Environment Information Monitoring, Journal of Computational Information Systems 8: 19, pp: 79197926.

[17] Murillo, F.A, Pena, M and M, D. (2012), Applications of WSN in Health and Agriculture, IEEE Communications Conference (COLCOM) Columbian, pp: 1-6.

[18] Mampentzidou, I., Karapistoli, E., and Economides, A.A., (2012), Basic guidelines for deploying wireless sensor networks in agriculture, in Ultra-Modern Telecommunications and Control Systems and Workshops (ICUMT), 2012 4th International Congress on. IEEE, 2012, pp. 864869.

[19] Liakos, T.A, Perlepes, V, Fountas, L and T, S.G. (2011), Wireless Sensor Network for Precision Agriculture, IEEE Panhellenic Conference on Informatics, pp: 397-402.

[20] Jiber, Y, Hamid, H and Ahmed, K. (2011), Precision agriculture monitoring framework based on WSN. In IWCMC, pages 2015-2020. IEEE

[21] Valente, J, Sanz, D, Baarientos, A, Cerro, J.D, Ribeiro, A and Rossi, C. (2011), An Air-Ground Wireless Sensor Network for Crop Monitoring, ISSN 1424-8220, pp: 6088-6108.

[22] [22] Li, S., Cui, J. and Li, Z. (2011), Wireless Sensor Network for Precise Agriculture Monitoring, Fourth International Conference on Intelligent Computation Technology and Automation, pp: 307-310.

[23] Atmga8 Microcontroller Datasheet, http://www.atmel.com/Images/Atmel-2486-8-bit-AVR-microcontroller-ATmega8 L datasheet.pdf
[24] MIB520CB Datasheet,http://www.memsic.com/support/documents/wireless sensor-networks /category/7-datasheets.html?download=144%3Amib520cb
[25] IRIS Mote Datasheet, http://www.dinesgroup.org/projects/images/pdf files /iris datasheet.pdf
[26] MDA100CBDatasheet,http://www.memsic.com/support/documentation/wireless-sensor-networks/category/7datasheets.html?download=141%Amda 100
[27] DHT11 Sensor Datasheet, Temperature and Humidity Module, http://www.micropik.com/PDF/dht11.pdf/
[28] Tiny OS, an open-source operating system for wireless embedded sensor networks, http://www.tinyos.net/
[29] Technical Guide. Agriculture 2.0 document version: v4.0 02/2013. Libelium communications Distribuidas S.L. http://www.libelium.com, 2013.
[30] Jawad, H, M., Nordin, R., Gharghan, S, K., et al. (2017), "Energy-efficient wireless sensor networks for precision agriculture: A review" Sensors 2017, *17*, 1781; doi:10.3390/s17081781. www.mdpi.com/journal/sensors.
[31] Rubala,J,I.,Anitha, D., (2017), "Agriculture field monitoring using wireless sensor networks to improving crop production" International Journal of Engineering Science and Computing. Volume 7 Issue No.3.
[32] Jaladi, A,R., Khithani, K., Pawar,P., et al. (2017), "Environmental Monitoring Using Wireless Sensor Networks(WSN) based on IOT" International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395 -0056, p-ISSN: 2395-0072, Volume: 04 Issue: 01.
[33] Ali, A., Ming, Y., Chakraborty,S., Iram, S., (2017) "A Comprehensive Survey on Real-Time Applications of WSN" www.mdpi.com/journal/futureinternet.