IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 1, August 2024

A Smart Farm Monitoring and Control System using Wireless Sensor Network

Ndubueze Herbert Otuosorochi
Department of Electrical/Electronic Engineering Technology
Federal Polytechnic of Oil and Gas Bonny, Rivers State, Nigeria
cossymasichii@gmail.com

Abstract: *Agriculture is one of the most important sector that accounts for economic growth in the developing countries of the world. Many developing countries are now focusing on agricultural development, yet the sector is not without challenges including climate changes, drought, flooding to mention but a few. These result in poor yield of agricultural products. In this work, we l developed a robust smart system to enhance both irrigation and flooding monitoring and control, leveraging on Wireless Sensor Networks (WSNs) to boost agricultural production. In the system's implementation, Arduino based instrumentation, integrated with temperature, soil moisture and water level sensor shall be adopted to monitor the agricultural environment, while reporting the status wirelessly through the Radio Frequency (RF) modules to the base station. The base station will evaluate the received data and either activates or deactivates the irrigation or drainage pump using specified threshold values. The remote reporting the state of farm shall be done by deploying a 900Mhz transmitter interfaced with the system's controller. This work shall be validated using an experimental test bed, which shall be used for field experiments, data collection and evaluation. The result of the work shall highlight the potentials of WSN technology in monitoring and control technology of both irrigation and flooding within the farm and in turn boost productivity.*

Keywords: wireless sensor network, irrigation and control, variable parameters

I. INTRODUCTION

Water is a basic component of all known life on earth, hence water can both sustain life in correct quantities and threaten life when it is not available or over abundant [3]. Water therefore is very precious natural resources that must not be wasted [4]. If too much water is applied to crops, problems arise consisting of runoff, erosion, leaching, waste of water, threat to plant life is threatened etc. If inadequate water is applied, different problems equally arise such as turf burnout, hence the need to control the quantity of water supplied to crops[5]. To this effect, mankind has continued to figure out how best to irrigate large areas of foliage through the use of automated irrigation systems. The idea of irrigation control is not new. Irrigation control stemmed as far back as the Egyptians along the river Nile about 5000 BC. The Chinese had irrigation by 5100 BC. By 5200 BC elaborate irrigation systems already used.

Now irrigation is practiced in all parts of the world where rainfall does not provide enough ground moisture such as in Borno State North East, Nigeria. Irrigation is maintained from the time a crop is planted to the time of harvest. Among the early devices used for irrigation include, lifting water from streams to higher lying fields which is a bucket set on one end of counter weighted pole**.** The Achimedes screw used for the same purpose is a cylinder containing a wide threaded screw turned by hand. The cylinder was set on an incline with the stream, and as the screw was turned, it lifted water to a higher level.

Irrigation control system has witnessed tremendous growth from time to time in line with prevailing technological advancement.[7] These trends are moving or changing from mechanical to electronic technology. The rapid development of sensing, computing and information technologies has introduced wireless sensing technology (WST) as a new concept on the management and control of irrigation systems [12]. The development of WST on irrigation control has indeed turned the fortunes of irrigation especially in optimal water use and increase in crop yield. Recently wireless sensing technology has become the centre of attraction for researchers due to wide application areas with low or no cost of maintenance after deployment in a targeted area. This technology allows automatic sensing and reporting without human intervention.

Definitely a smart farm system which deploys this technology (WSTs) will surely enhance agricultural production, which directly means increase in the gross domestic product (GDP) of the nation where such systems are deployed.

II. REVIEW OF RELATED WORKS

Zhejiang (2013), in his work titled 'Green House Management Using Wireless Sensor Networks' many wirelesses nodes were introduced to monitor and control the Green House parameters like humidity, water PH, Light intensity, temperature. This system is composed of sensor nodes for collecting data, base nodes for processing collected data, relay nodes for adjusting the environment inside a greenhouse and an environment server for storage and processing of collected data. He also constructed a test bed in the usual greenhouse in order to verify the performance of the system. In the project, mesh topology was deployed as the structure of the network. From the result, data acquisition and remote management of the system showed satisfactory performance. Result equally showed that the system has an advantage of robustness, reliability in data transmission, but energy consumption was one of the most challenging aspects of the networks at various stages. Consequently, network lifetime was shortened. This is the area the research hopes to improve upon.

Mitchel (2013), developed a node power optimization protocol called 'Energy-Efficient Medium Access Control Protocol for Wireless Sensor Networks. The main objective of the work was to minimize the power consumption by the node. In his work, a node module was configured to wake up at every 45 minutes interval for 5minutes just to transmit data to the base station. His work failed to test on the extra energy required for the transitions and moreover, the sleep duration of the nodes was too long. Despite his contributions, the power consumed by WSNnode was still relatively high and network disconnection among the nodes was sometimes observed. Our research intends to improve upon that by achieving more enhanced energy efficient performance protocol

III. THE PROCESS INVOLVE IN DATA ACQUISITION USING WIRELES SSENSOR NETWORKS

Temperature sensor unit is used to sense the ambient temperature of the farm so as to know the right time to irrigate the farm. In this work thermistor was used as the temperature sensor for the monitoring of the ambient temperature of the farm between 0-35 degrees. Figure 3.4 shows the thermistor.

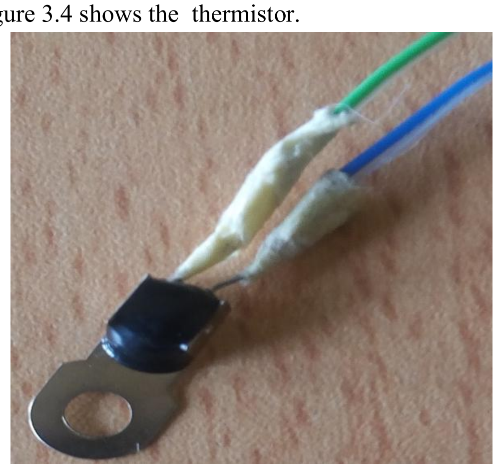
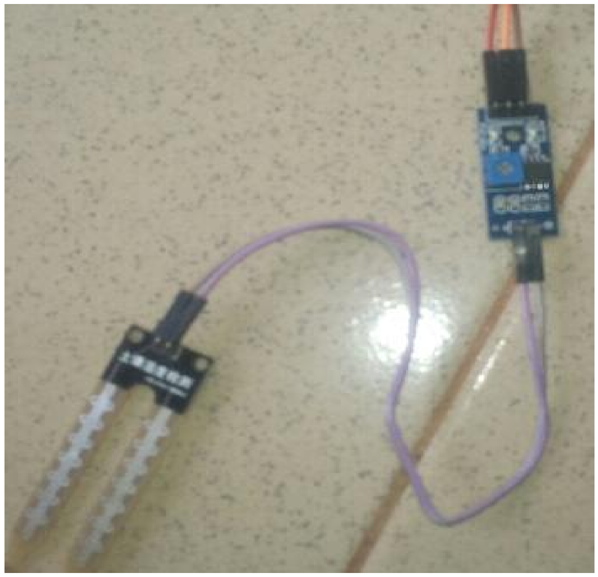


Figure 3.4: thermistor

Moisture sensor unit senses the moisture level of the soil to ascertain if the soil is dry or wet. It has a sensory probe and the control unit part, which work together to ascertain the current state of the farm. This sensor can be configured to operate in either digital mode or analog mode. In this work it was configured to operate in the digital mode. Figure 3.5 shows the snapshot of moisture sensor.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 1, August 2024



Moisture level sensor

IV. THE COMMUNICATION ARCHITETURE

I ***Arduino based (control unit)*** is used to process the received signal from the sensors nodes and then gives a corresponding output to the RF transmitter unit which transits an encoded signals corresponding outputs from the Arduino board (control unit) wirelessly to the base station. Which then turns ON or OFF the drainage or the irrigation pumps on or off. This unit is made up of an encoder (HT12E), RF transmitter (FS100A.

Figure 3.7 shows the snapshot of arduino board.

Figure 3.1: Arduino Board

RF Transmitter

RF Receiver

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.53

Volume 4, Issue 1, August 2024

The remote control system unit (RCSU) which can also be seen as the base station unit, is responsible for the switching ON and OFF of both the irrigation and drainage pump. It has a control unit, RF receiver, GSM transmitter, pumps, actuators and its own power supply unit. The control unit (arduino based) receives the sensor node wireless sensor network system unit (WSNSU) transmitted data via the RF receiver and decodes the message. The functions of the control unit are defined by the control program embedded into its ROM memory. It will continue to sample the received data and measure them against predefined thresholds. The microcontroller would energize or de-energize the relay depending on the threshold values, which would in turn start or stop the irrigation and drainage processes.

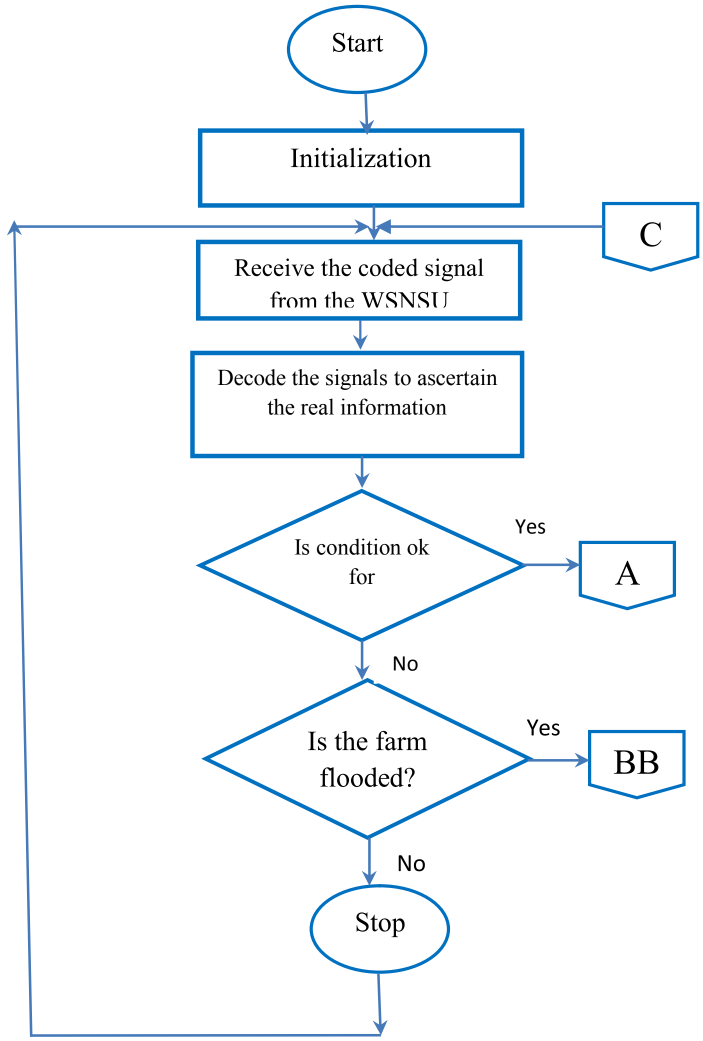
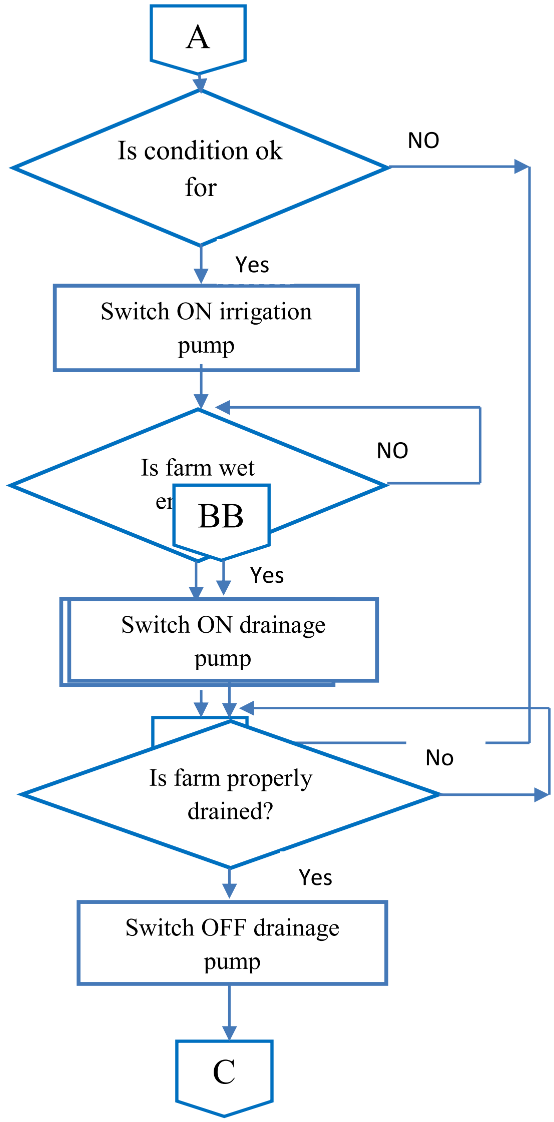


Figure 3.20a: Flowchart Diagram of RCSU.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 1, August 2024



[

Figure 3.20b: Flowchart Diagram of RCSU

V. DATA COLLECTION

From the experimental test bed, some data were collected and grouped into four (4). The first data known as Data_1, shown in appendix C is showing the behavior of the system when the Soil is dry and the temperature is conducive for irrigation. This was achieved by taking the ambient temperature, moisture level and water level of the farm at interval of 3 seconds after loading the controller with the control algorithm shown in appendix A. A total of 100 samples were taken.

Data_1 was used as a reference data in determining the behavior of the system when the soil needs to be irrigated and the temperature is conducive.

The second set of data, Data_2, shown in appendix D, depicts the response of the experimental test bed when the Soil is dry and the temperature is not conducive for irrigation.

The third data, Data_3, shown in appendix E, depicts the response of the experimental test bed when the Soil is moist with no flood detected. The fort data, Data_4, shown in appendix F, depicts the response of the test bed when the Soil is moist with flood detected.

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.53

Volume 4, Issue 1, August 2024

VI. RESULTS AND ANALYSIS

The recorded data was exported to Microsoft Excel for evaluation and analysis, using the information in appendix C, D, E and F to plot a graphs showing the system's response to variation of environmental features like soil moisture, water level and temperature of the farm.

Figure 4.5 shows a graphical representation of the behavior of the system when the soil is dry and the temperature is conducive for irrigation. Four (4) different temperature readings with their corresponding moisture level and water level values as well as irrigation and drainage pump state from the captured data of data_1 were used in the plotting of the graph, this is because using all will make the graph clumsy. From the graph it shows that as long as the temperature value is within range (0^0C - 35^0C) and the soil moisture sensor indicating low soil moisture, the irrigation pump comes ON and stays on as long as the sensor reading is indicating that the soil moisture level is low.

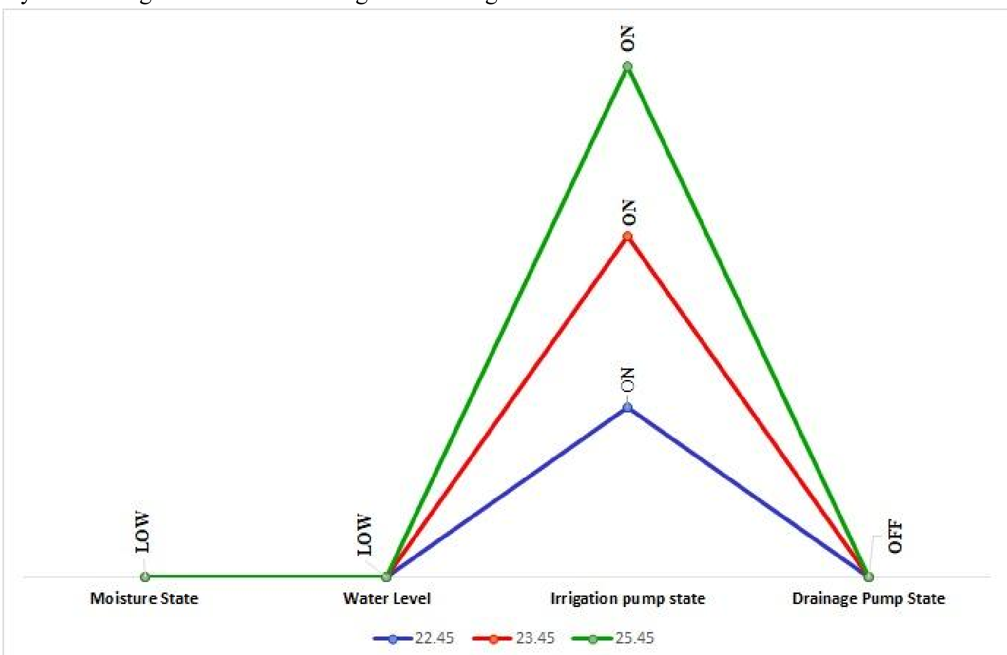


Figure 4.5: Graphical representation of the system's behavior when the soil needed to be irrigated and the temperature is within range (0 - 35 ^{0}C).

In figure 4.6 it shows a graphical representation of the behavior of the system when the soil is dry and temperature is not conducive for irrigation. Five (5) different temperature readings with their corresponding moisture level and water level values as well as irrigation and drainage pump state from the captured data of data_2 were used in the ploting of the graph. From the graph it shows that as long as the temperature value is not within range (0^0C - 35^0C), even when the soil moisture sensor is indicating low soil moisture, the irrigation pump remains OFF until it the temperature falls within range.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 1, August 2024

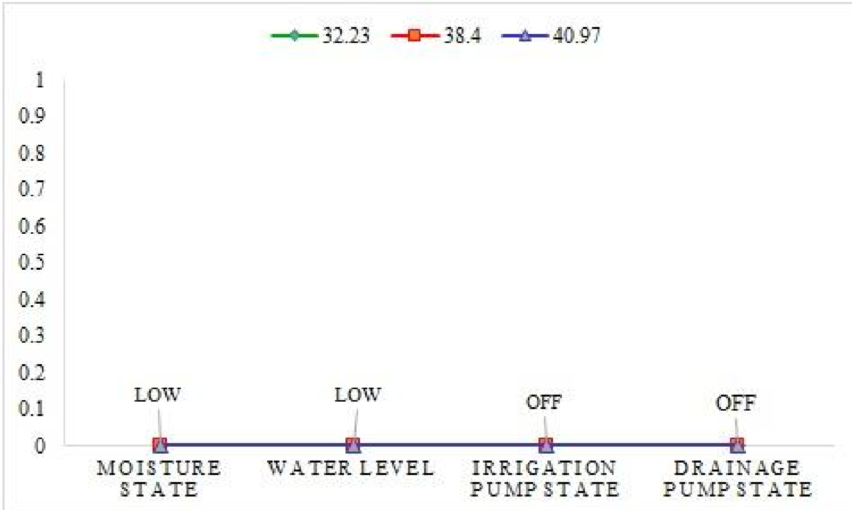


Figure 4.6: Graphical representation of the system's behavior when the soil needed to be irrigated and the temperature is not within range (0 - 35 ^{0}C).

In figure 4.7 it shows a graphical representation of the behavior of the system when the soil moisture is ok, water level low, which means no flooding has occured. Four (4) different temperature readings with their corresponding moisture level and water level values as well as irrigation and drainage pump state from the captured data of data_3 were used in the ploting of the graph. From the graph it shows that as long as the soil moisture sensor is indicating high soil moisture, which means it is ok and water level sensor not indicating that flooding has occurred, both the irrigation pump and the drainage pump will remain OFF.

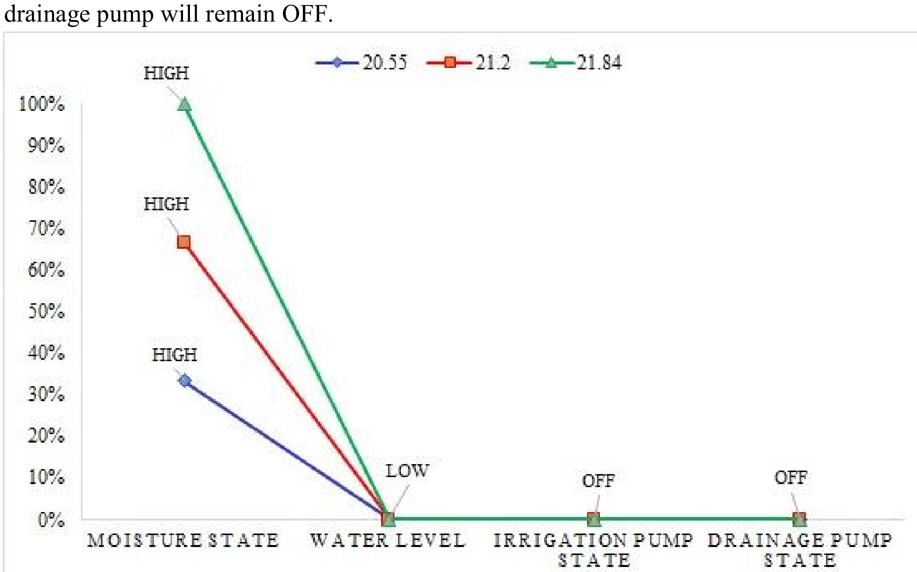


Figure 4.7: Graphical representation of the system when the Soil is moist is high, but within range, indicating no flood detection.

Finally figure 4.8 shows a graphical representation of the behavior of the system when the soil moisture is high and the water level is high indicating occurrence of flooding. Four (4) different temperature readings with their corresponding moisture level and water level values as well as irrigation and drainage pump state from the captured data of data_4 were used in the plotting of the graph. From the graph it shows that the drainage pump only comes ON when the soil moisture sensor is indicating high soil moisture level as well as the water level sensor indicating high water level. The

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 1, August 2024

drainage pump will remain ON until the water level sensor's output goes LOW indicating that the flood has been taking care of.

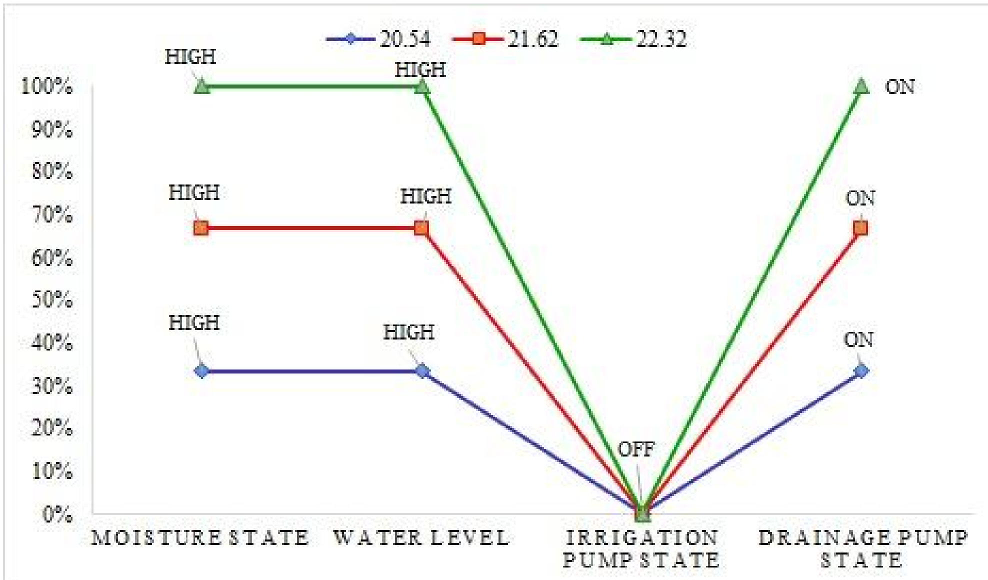


Figure 4.8: Graphical representation of the system when the Soil moist is very high, indicating flood detection.

From the figures above, this work has shown that the designed system was able to monitor and control the specified environmental factors within the experimental testbed region to enhance agricultural product. In addition to that, this system relays information about the farm status to the owner through the GSM transmitter leveraging on AT commands, keeping the farmer informed of the happenings in the farm.

VI. CONCLUSION

Agriculture is the process of producing strategic food and fiber in meeting of the fundamental needs of the people. This strategic value has many times been checked over throughout history with the disputes between the nations and environmental limitations. Nowadays where impacts of the global warming come about as the changes/unbalances in the climate conditions sustainability and the increase of the agricultural production is only possible with the collection of more data and analyzing the data and make use of them. Detection and the transmission of the data needed are possible with the efficient use of the information technology.

Wireless sensor network was developed and implemented in an experimental test bed. The WSN was used to monitor and relay the environmental factors within the test bed to a control system unit for actual control. Almost all farmers are concerned with resource (water, chemicals, fertilizers etc) management. This can be for many reasons including resource availability, runoff, and government regulations. In order to get the most out of available resources and minimize waste, WSN was used to predict resource requirements of a plant based on current and recent field measurements taken from sensors on the nodes installed in the farm. This system enhanced the productivity of agricultural product by creating the required conducive atmosphere.

REFERENCES

[1] Ayalaa K. J. (2007). "Microcontroller and their applications", *Penram International Journals,* 4(l), 31-32.

[2] Bautista, E. &Clemmens, A. J., (2006). "Response of ASCE Task Committee Test to open loop control measure". Journal of Irrigation, Flood and Drainage Engineering, 5(2), 109-118

[3] Bhuvaneswari, P. T. &Vaidehi, V. (2014). "Location Aided Energy Efficient Routing Protocol in Wireless Sensor Network". Master's Thesis Department of Electronics Engineering Madras Institute of Technology Anna University, Chennai, India.Mobile Control Application, 215-217.

[4] Gombachika, H. A. & Graham, A. B. (2012), 'Successful Deployment of a Wireless Sensor Network for Precision Agriculture in Malawi', The 3rd 6 IEEE International.

[5] Merriam, J. L., & Keller, J., (1998), "Farm irrigation system evaluation: a guide for management." Department of Agricultural and Irrigation Engineering, Utah State University, Logan, Utah.

[6] Miranda, F., Yoder, R. & Wilkerson, J.B. (2003), "A site-specific irrigation control system". ASAE Annual International Meeting 22-24.

[7] Mitchel, P., Anieke, J. I. &Seun, M. O. (2013). "Energy-Efficient Medium Access Control Protocol for Wireless Sensor Networks". *International Journal of Engineering & Technology IJET- IJENS*9.

[10] Perry, C. D., Dukes, M. D.&Harrison, K. A. (2004). "Effects of variable-rate sprinkler cycling on irrigation uniformity". ASAE Annual International Meeting, 1(2), l7.

[11] Praveen, K. &Jyoti, S. (2011), "Zone Based Routing Algorithm*". International Journal of Adhoc,* Sensor & Ubiquitous Computing (IJASUC), 2(2).

[12] Purnima, S.R.N., (2012), 'Design of Remote Monitoring and Control System with Automatic Irrigation System Using GSM-Bluetooth'. *International Journal of Computer Applications* 47(12), 888.

[13] Renter, D. C., & Everett, R. S. (2008). "Intelligent Control Based Fuzzy Logic for Greenhouse Irrigation System". International Conference on Computer and Communication Technologies in agriculture engineering, 128-131.

[14] Richard, G. A., Luis, S. P., Dirk, R., Martin, S. (2006). "FAO Irrigation and Drainage" Paper. No 56, 54-59.

[15] Rodoplu, & Meng et al (2012), "Minimum Energy Communication Network in WSN (MECN)". Journal of Electronics and Communication Engineering (IOSR-JECE) 9

[16] Sakthipriya N. (2014), 'An Effective Method for Crop Monitoring Using Wireless Sensor Network,' *Middle-East Journal of Scientific Research* 1127, © IDOSI Publications,

[17] Sokwoo, R. D. & Sheng, L. M. (2011). 'Application of Low-Power Sensor Networks in Irrigation Control', Proceedings of the World Congress on Engineering 2008 I, WCE 2011, 2-4, London, U.K.

[18] Zhejiang, L. M. (2013), "Green House Management Using Wireless Sensor Networks". International Journal of Distributed Sensor Networks 2(2), 11-19.

[19] NattapolKaewmard, Saiyan Saiyod, "Sensor Data Collection and Irrigation Control on Vegetable Crop Using Smart Phone and Wireless Sensor Networks for Smart Farm", 2014 IEEE Conference on Wireless Sensors (ICWiSE), pp. 106-112, October, 26-28 2014

[20] Migdall, S.; Klug, P.; Denis, A; Bach, H., "The additional value of hyperspectral data for smart farming," Geoscience and Remote Sensing Symposium (IGARSS), 2012 IEEE International , vol., no., pp.7329,7332, 22-27 July 2012

[21] Jhuria, M.; Kumar, A; Borse, R., "Image processing for smart farming: Detection of disease and fruit grading," Image Information Processing (ICIIP), 2013 IEEE Second International Conference on , vol., no., pp.521,526, 9-11 Dec. 2013

[22] Qiang Wang, Terzis A. and Szalay A., "A novel soil measuring wireless sensor network," Instrumentation and Measurement Technology Conference (I2MTC), 2010 IEEE , vol., no., pp.412,415, 3-6 May 2010

[23] Castello C.C., Fan J., Davari A. and Ruei-Xi Chen, "Optimal sensor placement strategy for environmental monitoring using Wireless Sensor Networks," System Theory (SSST), 2010 42nd Southeastern Symposium on , vol., no., pp.275,279, 7-9 March2010

[24] P.Elechi,S.OrikeandC.G.Duru(2022).GSM integrated control system for optimal hazard management, journal of microelectronics and solid state devices, 9(2), 43-55, Available At:https://www.researchgate.net/publications/363090479_GSM_Based_Interated_Control_System_For _Optimal_System_Management

[25] Lei Xiao; Lejiang Guo, "The realization of precision agriculture monitoring system based on wireless sensor network," Computer and Communication Technologies in Agriculture Engineering (CCTAE), 2010 International Conference On , vol.3, no., pp.89,92, 12-13 June 2010

[26] Jiber, Y.; Harroud, H.; Karmouch, A, "Precision agriculture monitoring framework based on WSN," Wireless Communications and Mobile Computing Conference (IWCMC), 2011 7th International vol., no., pp.2015,2020, 4-8 July 201

[27] Singh, S.N.; Jha, R.; Nandwana, M.K., "Optimal design of solar powered fuzzy control irrigation system for cultivation of green vegetable plants in Rural India," Recent [36] [45] Advances in Information Technology (RAIT), 2012 1st International Conference on , vol., no., pp.877,882, 15-17 March 2012

[28] Andreas F. Molisch, Kannan Balakrishnan, Chia-Chin Chong, Shahriar Emami, Andrew Fort, Johan Karedal, Juergen Kunisch, Hans Schantz, Ulrich Schuster, Kai Siwiak, IEEE 802.15.4a channel model - final report

[29] Md.Faruk AbdullahAlSohan and AfrozaNahar(2022).A low-powerwirelesssensor network for a smart irrigation system powered by solar energy Proceedings of the 2nd International Conference on Computing Advancements, Available at:https://doi.org/10.1145/3542954.3543031.