JUSIKOM PRIMA (Jurnal Sistem Informasi dan Ilmu Komputer Prima)
Vol. 5 No. 2, Februari 2022 E-ISSN: 2580 - 2879

Smart Farming- Drip Irrigation Controlled using LR-WPAN with hybrid Power

Albert Sagala, Janasde Romario Sitompul, Joel Laurent Hutauruk, Riado Sitorus
Institut Teknologi Del,
Toba Samosir, Indonesia
Corresponding Author: albert@del.ac.id

Abstract— **Agricultural sectors always need technology to get higher yields. Wireless Sensor Technology with LR-WPAN gives the opportunity to control the plat with minimum cost. In this paper, we developed a system that optimally waters agricultural crops based on a wireless sensor network technology. The scope in this paper consists of two main components: a hybrid power source and a communication system between end nodes with the gateway. The first component was designed and implemented in control box hardware using PLC (Programmable Logic Controller) to generate the power to all components (microcontroller, sensor, and actuator). The second is transmission data from end node to gateway by utilizing Zigbee protocol. The automation uses data from three soil moisture sensors as a trigger to the ON/OFF solenoid valve for watering the field.**
It may conclude that the system can work properly, the data from the field was sent real-time. Also, the hybrid power was working properly to supply power.

Keywords— **Wireless Sensor Network, IEEE 802.15.4, Zigbee, smart farming, LR-WPAN.**

I. INTRODUCTION

Agricultural systems in rural areas have many obstacles that make them less productive because cannot implement such technology. Various obstacles are faced such as the absence of electricity sources, lack of irrigation systems, and difficult access to land locations. Furthermore, many agricultural lands are less productive, especially during the dry season. There are so many influences that make the agricultural sector less productive. Among them is the unavailability of accurate data on land conditions that are affected by no electricity in an agricultural area. For this reason, a solution is needed to solve the problem, so that work in the agricultural sector can be helped.

Wireless sensor network (WSN) technology has been widely developed in various fields of public life, including in agriculture which promises to solve the problem that existed [1][2][3][4][7][14][15]. Many types of research did with different areas of focus research. In [3],[13], and [19], web-based monitoring is implemented to automate irrigation. A Zigbee protocol was used for transmitting the soil condition to the receiver in [7]. Scheduled irrigation using WSN is implemented in [8][10]. Furthermore, energy-efficient protocol for precision is elaborated in [5],[11],[12]. For the long-range, the protocol LoRa was also used for irrigation monitoring [20].

This paper examines the implementation of a soil moisture monitoring system using technology based on the IEEE 802.15.4 Low Rate Wireless Personal Area Network (LR-WPAN) for monitoring the drip irrigation system. And to overcome the unavailability of power sources, the research also developed a hybrid power subsystem using solar cells (PV) and the state electricity company (PLN). In [18], a stand-alone photovoltaic/wind energy hybrid generation system with MPPT for rural applications is the main problem to implementing technology with a lack of electricity. The same approach is also applied in [17] by combining PV-wind energy. So that all components obtain power from solar cells. In the testbed mounted three humidity sensors are used as a reference to activate the drip irrigation system [6],[9].

The remainder of this paper is organized as follows. Section II addresses a methodology to realize the research. Section III Result and Discussion, Finally, concluding remarks are presented in Section IV.

II. METHODOLOGY

The overall system consisted mainly of two blocks: a power system using hybrid PV-PLN which connected with drip irrigation consists of field, tank, and end-node (transmitter), receiver, and database – a web server for monitoring. As seen in Figure 1 PLC (Programmable Logic Controller) was used for automatic transfer switch (ATS) between PV and PLN systems. It uses a primary power resource for all components: sensors, actuators, microcontrollers, PLC, etc. The solenoid valve would open/close based on three humidity sensor measurements in the field. The flow process can be seen in Figure 2. An ultrasonic sensor is applied in order to monitor the water tank so that the pump will be open/closed.

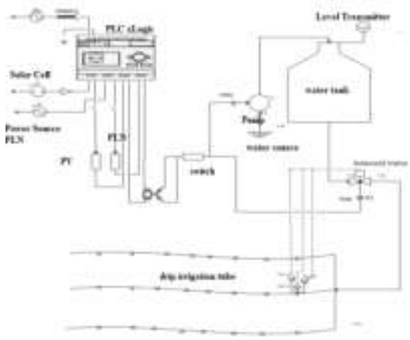

Figure 1 Process Flow Drip Irrigation System with Power hybrid mechanism

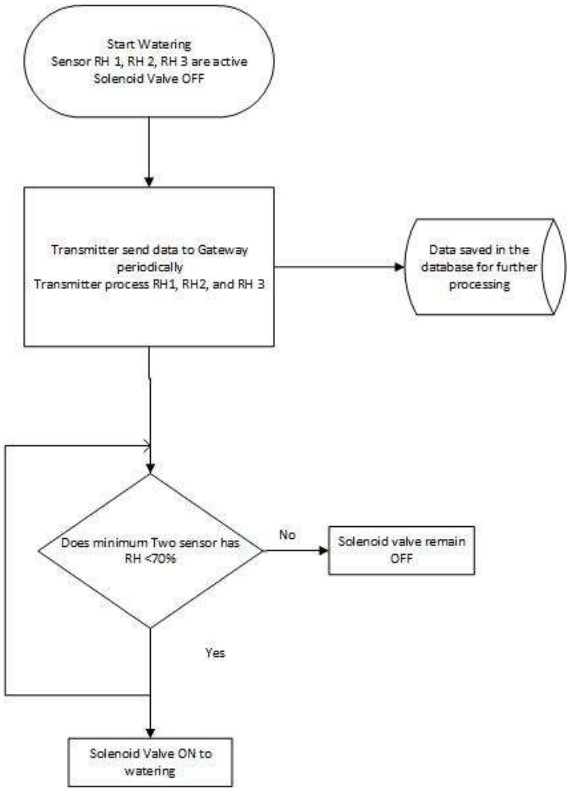

Figure 2 A flow chart of ON/OFF solenoid valve

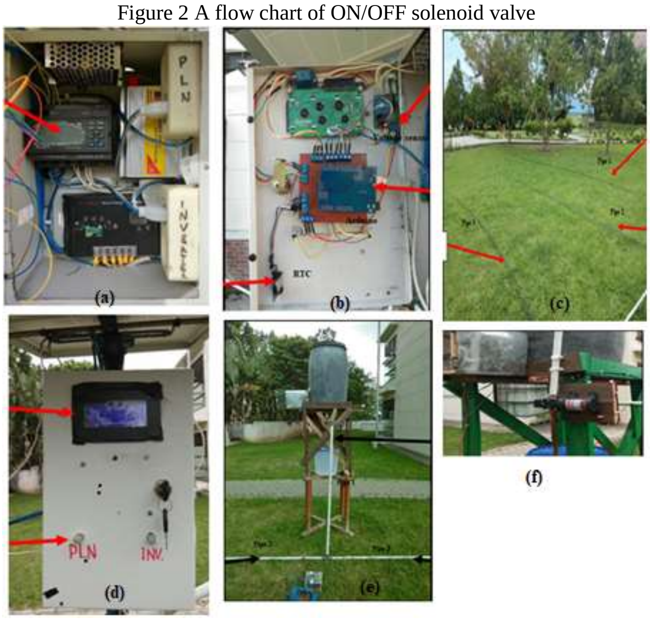

Figure 3 Testbed Implementation (a) PV-PLN (b) Zigbee Receiver (c) field experiment (d) Panel box (e) Drip Irrigation Tank (f) Pump installation

A. *Performance Evaluation on Communication System*

System testing needs to be conducted to ascertain whether the system developed has been able to work as expected and can work well. System testing also needs to be executed to find out what parameters can affect the performance of the system being built. Here are some tests conducted on the system that was built.

B. *Range evaluation on XBee S2C (Zigbee)*

The test was conducted to determine the range of communication tools applied. It was carried out by measuring the distance between the transmitter and the receiver in which the data was received correctly. The receiver was installed in a fixed position, while the transmitter moved away. As can be seen in Table 1, the Zigbee transmission successfully transmitted data from distance 0 m until 120 m, whereas it failed for a distance longer than 125 m.

Table 1 Range transmission evaluation

No	Distance Tx and Rx (m)	Success/Failed	Power (dB)	Received
1	0	Success		-14
2	10	Success		-64
3	20	Success		-72
4	30	Success		-75
5	40	Success		-78
6	50	Success		-80
7	60	Success		-82
8	70	Success		-85
9	80	Success		-87
10	90	Success		-93
11	100	Success		-95
12	110	Success		-110
13	120	Success		-110
14	125	Failed		None
15	130	Failed		None

C. *Throughput evaluation*

Throughput testing did by transferring some data packets from the sensor installed in the irrigation system. We monitor the data received using XCTU to get the throughput for different ranges. Due to the limited period to experiment, we only measure 8 meters as seen in Figure 3.

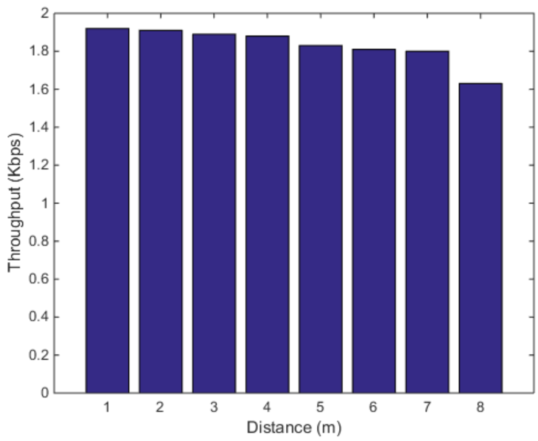

Figure 4 Throughput vs Distance

D. *Drip Irrigation evaluation*

In this experiment, the feasibility of the drip irrigation hose was tested. The feasibility test was determined by the uniformity of water droplets coming out of each emitter at each drip irrigation hose. Irrigation uniformity or what is called Distribution Uniformity (CU) calculated by the Equation below:

$$DU = 100\% \times Q_n/Q_a$$

with DU: Distribution of uniformity

Q_n= Average debit from 25% of low debit

Q_a= Average debit from all emitter

For the experiment, we make two scenarios (1) Installed drip irrigation (DI) in a flat area (Fig. 5 & Fig.7) and (2) installed in slope area (Fig. 6 & Fig.8). This consideration is based on research conducted in [16].

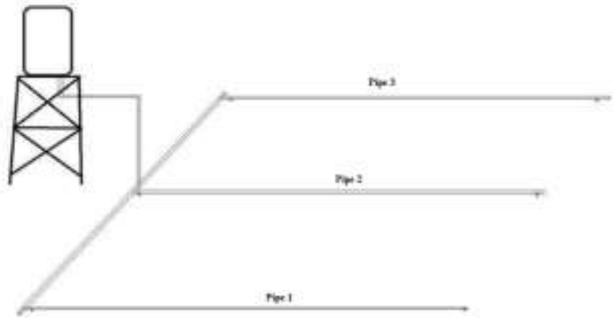

Figure 5 Flat DI system

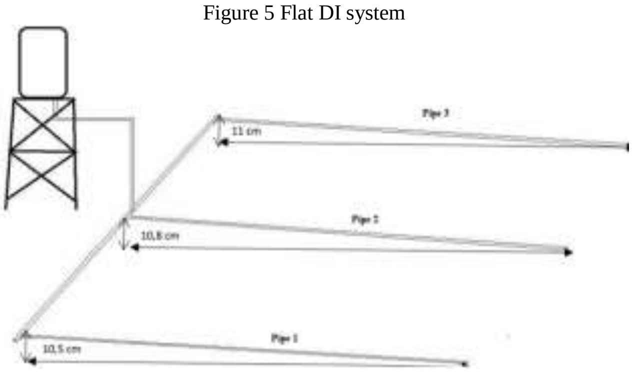

Figure 6 Slop DI system

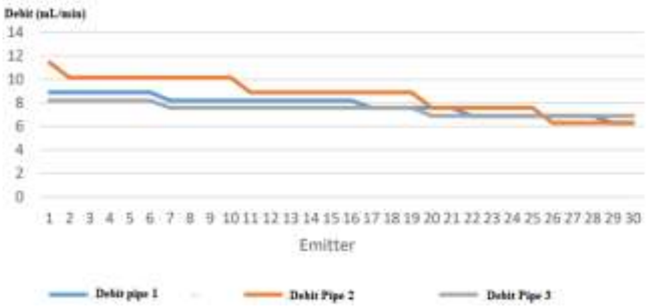

Figure 7 Flow rate (Debit) on flat DI system

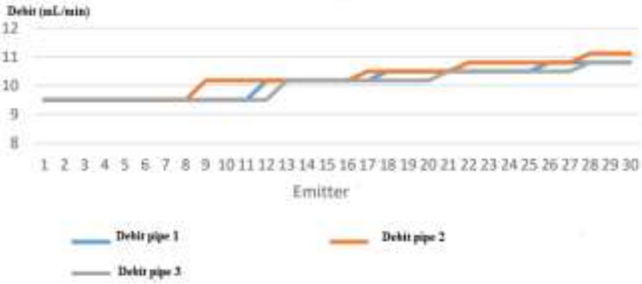

Figure 8 Flow rate (Debit) on slop DI system

In the first experiment, the DU of each drip irrigation hose at pipe 1, pipe 2, and pipe 3 comprises 84.5%; 78.29%; and 92.4% respectively. Whereas for the second experiment, the DU was 93.9%; 92.5%; 94.6%. It concluded that the second experiment produced more consistent water flow than the first experiment and make a conclusion that the uniformity of water droplets coming out of the emitters may be regulated by adjusting the slope of the drip irrigation hose at the ground surface.

Humidity Sensor YL-69

Soil moisture sensor YL-69 is a relative humidity (RH) sensor that detects moisture in the soil. The sensor consists of two probes that are useful for transferring a current through the ground and reading the resistance to get the value of the humidity level. If the soil moisture is higher then the resistance value on the sensor gets smaller.

We did testing for three moisture sensors YL-69 with nine measurements from low moisture (dry) to high moisture (wet). The experiment results were seen in Figure 9. It concluded that all three sensors have a good performance in linearity. The higher moisture would imply a lower voltage on the sensor output as seen in Figure 9. All RH sensors have linearity testing higher than 0.9 as seen in Table 2.

Table 2 Sensor linearity testing

No	Sensor	Linearity (R^2)
1	RH 1	0.99
2	RH 2	0.92
3	RH 3	0.99

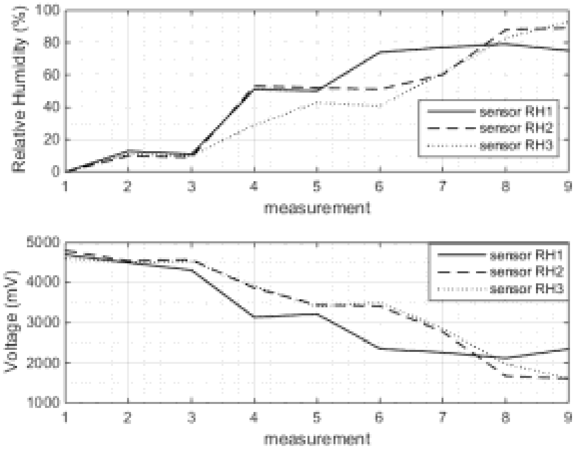

Figure 9 Measurement of three RH sensors

E. I/O Program in PLC

To provide input to the PLC, a voltage sensor is used to measure the battery voltage used by PV and Real-Time Clock (RTC) to determine the scheduling of charging and discharging PV batteries. The sensor is programmed in the Arduino IDE. Sensor output is processed into digital data as output in the form of one channel relay as an actuator. The actuator would be a digital input for the xLogic PLC. Figure 10 shows the schematic design of the input device for the PLC.

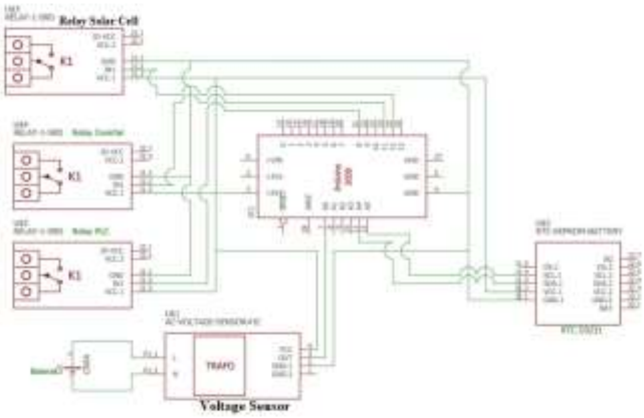

Figure 10 Schematic design of sensors and actuators in generating systems

F. Arduino-XLogic PLC Input Device Integration

In the schematic design, three relays are displayed in addition to the relay have by the PLC. The first is used for the solar cell, the second for the inverter, and the third for PLC relay. All works are triggered by the value of the voltage sensor and scheduling charging/discharging by the RTC.

G. Transmitter (Tx)

The transmitter is equipped with three humidity sensors connected to the Arduino and the XBee Shield Module which are used to retrieve and process analog data from the sensor. The transmitter functions as a data collector from the measurement of the humidity sensor while the receiver functions to receive data from the transmitter. The Design of the transmitter is seen in Figure 11 and Figure 12.

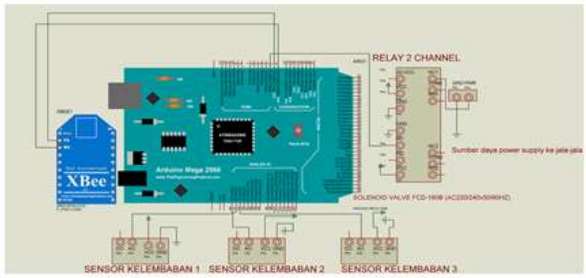

Figure 11 Wiring transmitter

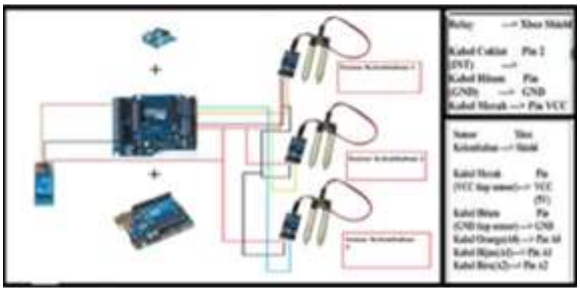

Figure 12 Physical wiring

H. Receiver (Rx)

In the receiver section, it uses an XBee module connected to the XBee USB Adapter which receives data sent by the transmitter. The data received sent to the computer using a USB serial connection. Thus, it displayed to the user. The design of the receiver seen in Figure 13.

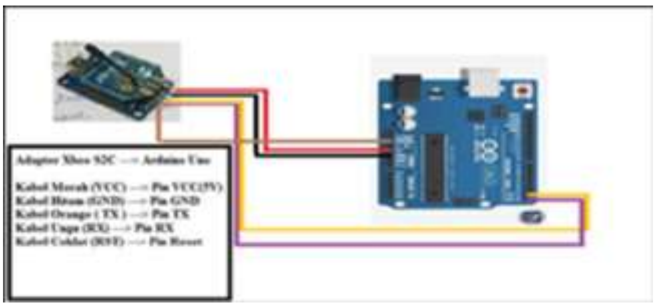

Figure 13 Receiver-Physical Wiring

I. Drip Irrigation System and Actuator

The drip irrigation system in this product uses two types of sensors, namely the soil moisture sensor and the ultrasonic sensor. Soil moisture is used to check soil conditions and ultrasonic is used to check water conditions in water drums. In the design of drip irrigation systems which are a burden on hybrid plants, the value of the humidity sensor and ultrasonic sensor are respectively used as indicators for the solenoid valve and water pump. Figure 14 is a schematic design of a drip irrigation system.

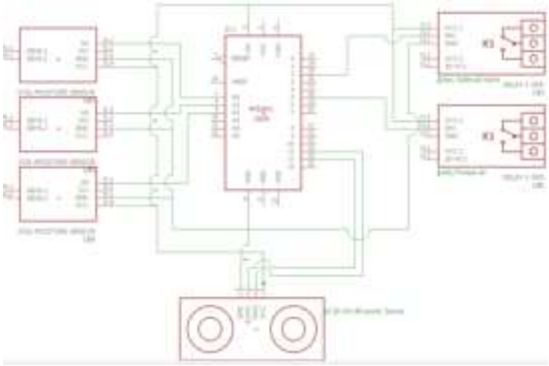

Figure 14 a schematic design of a designed drip irrigation system

III. RESULTS AND DISCUSSION

The implementation includes software and hardware applications to produce products that can communicate data wirelessly. In this implementation, hardware such as Arduino Uno, Humidity Sensor, XBee Shield, and XBee S2C has been successfully implemented as seen in Figure 15.

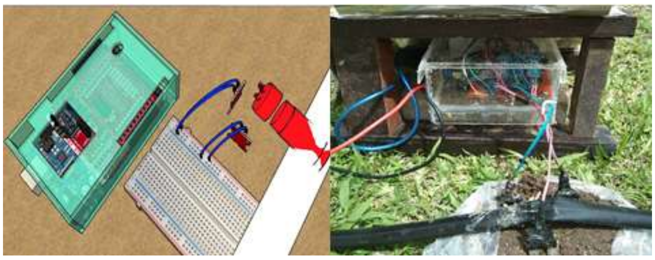

Figure 15 Xbee Transmitter

The XBee paired with a humidity sensor triggers a solenoid valve to open or close the water. The land condition is monitored by the web monitoring implemented in the Raspberry Pi as seen in Figure 16. The communication on transmitter and receiver uses the Xbee module explained in the previous section.

Figure 16 Xbee receiver

IV. CONCLUSION

In the research conducted, the hybrid generator system was implemented to overcome the unavailability of electricity in rural areas. So that all components obtain resources from solar cells or from general electric. Three humidity sensors are placed on the drip irrigation plate. In realtime the measurement data is sent to the Zigbee gateway which will be the reference for the open and close solenoid valve for irrigation. Water availability can be detected with an ultrasonic sensor mounted on the main tank, so that the relay system of the PLC can be used to start and die the water pump. All components can work well, further research can be done to cover a wider area.

ACKNOWLEDGMENT

The authors are deeply grateful to the Faculty of Informatics and Electrical Engineering. The authors also gratefully acknowledge the helpful colleagues at Electrical Engineering Department.

REFERENCES

[1] Y. G. Lin, "An Intelligent Monitoring System for Agriculture Based on Zigbee Wireless Sensor Networks", Advanced Materials Research, vol. 383, no. 1, pp. 4358-4364, 2012.

[2] Y. Lin, "Design of ZigBee wireless sensor networks nodes for agricultural environmental monitoring", Energy Procedia, vol. 11, pp. 1483-1490, 2011.

[3] M. Usha Rani, S. Kamalesh, "Web-based service to monitor automatic irrigation system for the agriculture field using sensors", Advances in Electrical Engineering (ICAEE) 2014 International Conference on, pp. 1-5, 2014.

[4] L. L. Pfitscher, D. P. Bernardon, L. M. Kopp, M. V. T. Heckler, J. Behrens, P. B. Montani, B. Thomé, "Automatic control of irrigation systems aiming at high energy efficiency in rice crops", Devices Circuits and Systems (ICCDCS) 2012 8th International Caribbean Conference on, pp. 1-4, 2012.

[5] Sonam Maurya, Vinod Kumar Jain, "Energy-Efficient Network Protocol for Precision Agriculture: Using threshold sensitive sensors for optimal performance.", Consumer Electronics Magazine IEEE, vol. 6, no. 3, pp. 42-51, 2017.

[6] Jobish John, Vinay S Palaparthy, Shahbaz Sarik, Maryam Shojaei Baghini, Gaurav S Kasbekar, "Design and implementation of a soil moisture wireless sensor network", Communications (NCC) 2015 Twenty First National Conference on, pp. 1-6, 2015.

[7] Pravina B. Chikankar, Deepak Mehetre, Soumitra Das, "An automatic irrigation system using ZigBee in wireless sensor network", Pervasive Computing (ICPC) 2015 International Conference on, pp. 1-5, 2015.

[8] Joseph Haule, Kisangiri Michael, "Deployment of wireless sensor networks (WSN) in automated irrigation management and scheduling systems: a review", Science Computing and Telecommunications (PACT) 2014 Pan African Conference on, pp. 86-91, 2014.

[9] G Kavianand, V M Nivas, R Kiruthika, S Lalitha, "Smart drip irrigation system for sustainable agriculture", Technological Innovations in ICT for Agriculture and Rural Development (TIAR) 2016 IEEE, pp. 19-22, 2016.

[10] Yousef E. M. Hamouda, "Smart Irrigation Decision Support Based on Fuzzy Logic Using Wireless Sensor Network", Promising Electronic Technologies (ICPET) 2017 International Conference on, pp. 109-113, 2017.

[11] Asmita Singh, Abhishek Tyagi, Sindhu Hak, "Energy Efficient WSN for Precision Agriculture – Using Modified Zonal Stable Election Protocol", Signal Processing and Integrated Networks (SPIN) 2019 6th International Conference on, pp. 352-356, 2019.

[12] Rajinder Kumar Math, Nagaraj V Dharwadkar, "A wireless sensor network based low cost and energy efficient frame work for precision agriculture", Nascent Technologies in Engineering (ICNTE) 2017 International Conference on, pp. 1-6, 2017.

[13] Shweta B. Saraf, Dhanashri H. Gawali, "IoT based smart irrigation monitoring and controlling system", Recent Trends in Electronics Information & Communication Technology (RTEICT) 2017 2nd IEEE International Conference on, pp. 815-819, 2017.

[14] Sachin Aggarwal, Anil Kumar, "A Smart Irrigation System to Automate Irrigation Process Using IOT and Artificial Neural Network", Signal Processing and Communication (ICSPC) 2019 2nd International Conference on, pp. 310-314, 2019.

[15] Prateek Jain, Prakash Kumar, D.K. Palwalia, "Irrigation management system with micro-controller application", Electronics Materials Engineering and Nano-Technology (IEMENTech) 2017 1st International Conference on, pp. 1-6, 2017.

[16] Dhawan Singh, Aditi Thakur, "Designing of Smart Drip Irrigation System for Remote hilly Areas", Parallel Distributed and Grid Computing (PDGC) 2018 Fifth International Conference on, pp. 90-94, 2018.

[17] R. Karthikeyan, P. Mahalakshmi, N. GowriShankar, "Wireless sensor networks for efficient irrigation system using hybrid pv -wind system", Advances in Electrical Engineering (ICAEE) 2014 International Conference on, pp. 1-5, 2014.

[18] R. Karthikeyan, P. Mahalakshmi, N. Gowri Shankar, "Stand-alone photovoltaic/wind energy hybrid generation system with MPPT for rural applications", Computing Communications and Networking Technologies (ICCCNT)2013 Fourth International Conference on, pp. 1-6, 2013.

[19] Saima Maqbool, Nidhi Chandra, "Real Time Wireless Monitoring and Control of Water Systems Using Zigbee 802.15.4", Computational Intelligence and Communication Networks (CICN) 2013 5th International Conference on, pp. 150-155, 2013.

[20] Ravi Kishore Kodali, Mohan Sai Kuthada, Yatish Krishna Yogi Borra, "LoRa Based Smart Irrigation System", Computing Communication and Automation (ICCC)