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Smart Aquaponic System based Internet of Things (IoT)

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Abstract: *Getting appropriate water source for fish and plant cultivation seems difficult. Moreover, the agricultural production is decreasing due to narrower lands so that land- and water-saving technology combined with a variety of vegetable is important to produce maximum yield. Aquaponics is a sustainable agriculture system in a symbiotic environment by combining aquaculture and hydroponics. This water system should flow on the planting medium periodically to ensure the plants get the nutrients, while the water can be filtered properly by the medium. This research designed a smart aquaponics system that could control and monitor the degree of acidity, water level, water temperature, and fish feed that were integrated with internet-based mobile application. In this system, there was a sensor installed to retrieve data, which was then transmitted to Ubuntu IoT Cloud server that could be accessed in real time through the internet network. Thus, the quality and water circulation were well- preserved. Results showed that the success rate of measurement for ultrasonic sensor was 99.94%, pH sensor of 92.35%, and temperature sensor of 97.91%. The temperature and pH water pool that were suitable for aquaponics ranged between 20-300C and 7-75 and the monitoring system proceeded as expected.*

Keywords*:* *Aquaponics*

I. INTRODUCTION

In this chapter we are introducing our Smart Aquaponics System and represent the basic concept of how the system works and features.

1.1 Project Statement:

Aquaponics is related to the combination of both hydroponics (plant framing) and fish farming with the reuse of water. It can also be referred has Organic farming has which doesn't contain any chemical fertilizer instead of it uses the bacteria and waste of fish as fertilizer through the water. Ammonia in fish waste is broken down by bacteria and converted into nitrites and then nitrates to be used as fertilizer for the plants. Our project implements an IoT system in Aquaponics to check the parameters of water so that it can be used for nourishing the plants and the fishes growing in them.

1.2 Purpose

The Proposed system manages to limit water usage, the number of waste materials in the water, and the need for synthetic vegetable fertilizers. Aquaponics also allows building horticulture farms in areas where this normally would not be possible: polluted soil, urban areas, or infertile areas.

1.3 Features

• Sensing Parameters- Temperature, PH Level, TDS, Soil Moisture, Water Level • Store data on Amazon AWS or Google Cloud. • Visualization and patient monitoring on the Web and Android App. • Fully Wireless • Protocol Used: MQTT • AI-based algorithm for predicting water Quality. • Economically feasible system. • Real-time notification to users.

1.4 Basic concepts

Aquaponics is be related to the combination of both hydroponics (plant framing) and fish farming with reuse of water. It can also be refereed has Organic farming has it 3 doesn't contain any chemical fertilizer instead of that it uses the bacteria and waste of fish as fertilizer through the water. Ammonia in fish waste is broken down by bacteria and converted into nitrites and then nitrates to be used as fertilizer for the plants. Our project implements an IoT system in Aquaponics to check the parameters of water so that it can be used for nourishing the plants and the fishes growing in them. The one of important parts is the bacteria which converts the fish waste into manure for plants. The entire system is monitored as variation in the levels of from optimum range will lead to the death of plants and fish. The project includes ESP32, Sensors like TDS, PH, Soil Moisture, temperature humidity sensor for transmitting data over the internet. The value transmitted by the microcontroller is shown on LCD as well as on mobile application can control the water pump through it. The detected value is sent as a message to thefarmer.

II. LITERATURE SURVEY

In this chapter we have done research on the existing system and improve our system with new feature and uses based on existing system limitation. • R. Mahkeswaran and A. K. Ng, "Smart and Sustainable Home Aquaponics System with Feature-Rich Internet of Things Mobile Application," 2020 6th International Conference on Control, Automation and Robotics (ICCAR), 2020, pp. 607-611, doi: 10.1109/ICCAR49639.2020.9108041. - The proposed smart and sustainable home aquaponics system consists of various sensors, actuators, and microcontroller with internet connectivity to continuously monitor, control, and record fish tank water and ambient air quality. Healthy growth of fish and plants are ensured by sending an early warning to the user in the event of any abnormal system condition via a push notification in a feature-rich internet of things (IoT) mobile application. Furthermore, appropriate actuators are automatically operated to rectify abnormalities in a timely manner. Plant grow lights and fish feeder are also automatically controlled to optimize fish and plant growth. All sensor readings and actuator statuses are intuitively displayed to the user in real time through the IoT mobile application and securely sent to an online spreadsheet for storage and further analysis. Measurement results successfully demonstrate the efficacy of the proposed home aquaponics system to grow healthy fish and plants, with minimal operational costs and human intervention. • A. K. Pasha, E. Mulyana, C. Hidayat, M. A. Ramdhani, O. T. Kurahman and M. Adhipradana, "System Design of Controlling and Monitoring on Aquaponic Based on Internet of Things," 2018 4th International Conference on Wireless and Telematics (ICWT), 2018, pp. 1-5, doi: 10.1109/ICWT.2018.8527802.. – The purpose of this research is to make a monitoring system of water temperature and water value of pH in aquaponic's system. It also adds controlling system to keep aquaponic's environment stable and to feed fish automatically through Internet of things. This research is prototype of monitoring and controlling system that applicated in aquaponic and can be access 5 from web interface. The result of this research are water value of pH, water temperature monitoring system and controlling system that use websocket's framework to keep the system running in the real time operation. Two Arduino devices are used as the data taker and the executor in controlling system. Meanwhile a Raspberry Pi device is used as a web server and the gateway, so it can be accessed in web interface. • R. Yuhasari, R. Mardiati, N. Ismail and S. Gumilar, "Fuzzy Logic-Based Electrical Conductivity Control System in Aquaponic Cultivation," 2021 7th International Conference on Wireless and Telematics (ICWT), 2021, pp. 1-4, doi: 10.1109/ICWT52862.2021.9678423. - This study developed an EC content control system in aquaponics cultivation using Fuzzy logic control. The output of the fuzzy was the duration of the pump motor to drive the motor which will pour ABmix into the growing media of the aquaponics system. We did some testing to find out how well this fuzzy system performed. The results showed that this fuzzy logic system could control the aquaponics EC value. In addition, this fuzzy system fitted and ran well without overshoot. • A. Riansyah, R. Mardiati, M. R. Effendi and N. Ismail, "Fish Feeding Automation and Aquaponics Monitoring System Base on IoT," 2020 6th International Conference on Wireless and Telematics (ICWT), 2020, pp. 1-4, doi: 10.1109/ICWT50448.2020.9243620. - In this research, a monitoring system was designed for pH and TDS in aquaponics and automation of fish feeding based on scheduling and level of need. Monitoring of pH and TDS as well as automation of fish feeding is done through an Android-based application. Fish feeding is carried out according to a schedule with a specified feed weight. The monitoring system for pH and TDS are carried out in real-time. The sensors used in this research are a pH sensor to measure pH values and an analog TDS sensor to measure total TDS. The

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communication system used is based on IoT technology. Based on the test results, it is found that the average difference between the readings of the pH sensor and the pH meter is 0.66% and the average difference between the readings of the TDS sensor and the TDS meter is 2.588%.

III. METHDOLOGY

Smart Aquaponics System

Smart aquaponics system is the development concept of bio-integrated farming system combined with internet of things-based electronic technology. This technology is designed to utilize water containing excess feed nutrients from aquaculture ponds or containers as a source of nutrition or hydroponic growing medium. Thus, the efficiency and effectiveness of feed and plant nutrition can be conducted[9]. Plant used in this present research was lettuce (Lactuca Sativa L.) and tilapia as the fish. This research used aquariums and pipes that had been modified as a place to plant.

Internet of Things

Internet of Things (IoT) can be divided into some layer architectures. The first layer is the perception layer, which functions to read and collect information from the physical environment. Then, the data will be used in the application layer. The perception layer is responsible for converting data into signals sent through the network so that it can be read by the application layer, for instance, the use of barcodes by minimarkets. In the barcode, there are data such as name, price, and stock of goods[10].

Quality of Service (QoS)

Quality of Service (QoS) is a method measuring how well the network and attempted to define the characteristics and properties of a service. In QoS, there are several parameters namely throughput, packet loss, and latency [11].

System DesiGn

Based on Figure 1, the system design consists of several system components covering microcontroller,sensor, Android and web interface, local display, back up water, pump, fish feeder, notification, and emergency source.

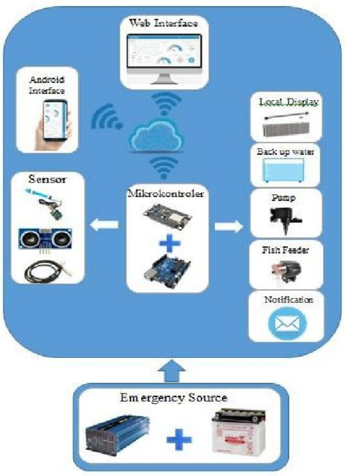

Figure 1. System Design

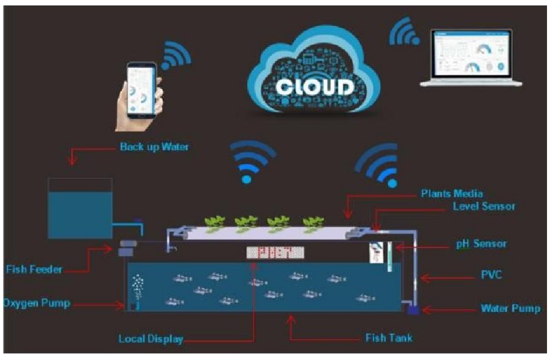

Figure 2. General Overview of the System

IV. RESULTS AND DISCUSSION

4.1 Testing of Ultrasonic Sensors

This test aims to adjust the measurement results of ultrasonic sensors with the measurement results of manual procedures using a ruler. Moreover, this test proposes to find out the error value generated by reading ultrasonic sensors on changes in water levels in the aquarium.

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Table 1. Results of Ultrasonic Sensor Testing

Measurement No.	(M)	Water Level (cm) Ultrasonic Sensor	Manual	Success (%)	*Error* (%)
1	M 1	8	8	100	0
2	M 2	11	11.5	99.57	0.43
3	M 3	13	13	100	0
4	M 4	16	16	100	0
5	M 5	19	19	100	0
6	M 6	24	24	100	0
7	M 7	27	27	100	0
8	M 8	5	5	100	0
9	M 9	6	7	99.86	0.14
10	M 10	9	9	100	0
			Average (%)	99.943	0.057

The results of ultrasonic sensor testing can be seen in Table 1, which shows that the biggest error value is 43% and the smallest error is 0%. Meanwhile, the average error is 57% with an average success of 99.943%.

4.2. pH and Temperature Sensors Testing

This test is done by inserting a probe from the sensor of pH meter into water with different degrees of acidity (pH). This test aims to calibrate the pH sensor and to determine the value of the acidity of the aquarium or container water. The results of the sensor readings are then compared to the digital pH meter. At the pH sensor, there is also a water temperature sensor which is used in the test simultaneously.

Table 2. Results of Acidity Testing (pH)

No.	Voltage	Acidity Level (pH) pH Sensor	MeterDigital pH meter	Success (%)	*Error* (%)
1	2.08	6.61	6.6	99.85	0.15
2	2.08	6.62	6.6	99.97	0.3
3	2.08	6.60	6.6	100	0
4	2.07	6.61	6.7	98.7	1.3
5	2.08	6.63	6.7	98.95	1.05
6	2.20	7.02	7.8	88.89	11.11
7	2.19	7.01	7.8	88.74	11.26
8	2.19	7.00	7.8	88.58	11.42
9	2.19	7.00	7.8	88.58	11.42
10	2.18	6.99	7.7	89.85	10.15
11	2.20	7.03	7.9	87.63	12.37

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No.	Voltage	Acidity Level (pH)		Success(%)	*Error* (%)
		pH Meter pHSensor	Digital meter		
12	2.20	7.02	7.8	88.89	11.11
13	2.21	7.02	7.8	88.89	11.11
14	2.14	7.02	7.8	88.89	11.11
15	2.20	7.02	7.8	88.89	11.11
			Average (%)	92.353	7.67

Based on Table 3 the results of testing the pH sensor for the value of acidity (pH) meter in 15 tests with a span of one minute in each test show the largest error value of 12.37% and the smallest value of 0%, meanwhile the average error of 7.67% and average success of 92.353%.

Table 3. Results of Temperature Testing

No.	Voltage	Temperature (^oC)		Success (%)	*Error* (%)
		Tempt Sensor	Digital Thermometer		
1	2.08	28	28.1	99.65	0.35
2	2.08	29	28.1	96.8	3.2
3	2.08	29	27.9	96.1	3.9
4	2.07	28	27.9	99,65	0.35
5	2.08	28	27.9	99.65	0.35
6	2.20	29	27.8	95.7	4.3
7	2.19	29	27.8	95.7	4.3
8	2.19	28	27.8	99.3	0.7
9	2.19	29	27.8	95.7	4.3
10	2.18	29	27.8	95.7	4.3
11	2.20	28	27.8	99.3	0.7
12	2.20	28	27.7	98.92	1.08
13	2.21	28	27.7	98.92	1.08
14	2.14	28	27.7	98.92	1.08
15	2.20	28	27.6	98.6	1.4
Average (%)				97.907	2.09

The temperature values in 15 tests with a span of one minute in each test can be seen in table 4. The biggest error value is 4.3% and the smallest value is 0.35%, whereas the average error amounted of 2.09% and the average success of 97.907%

4.3 Server Testing

This study uses one of the IoT platform servers namely Ubidots. The process of sending data to the Ubidots server are conducted by an account id in the form of token via a WiFi network. In this study, only one device with 4 variables was used. Every data sent from NodeMCU is further stored in one variable. Since each sensor has different variables, the data sent sensor will not be confused by the remaining data sensors as seen in figure 3 and 4.

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Figure 3. Dashboard Ubidost Interface

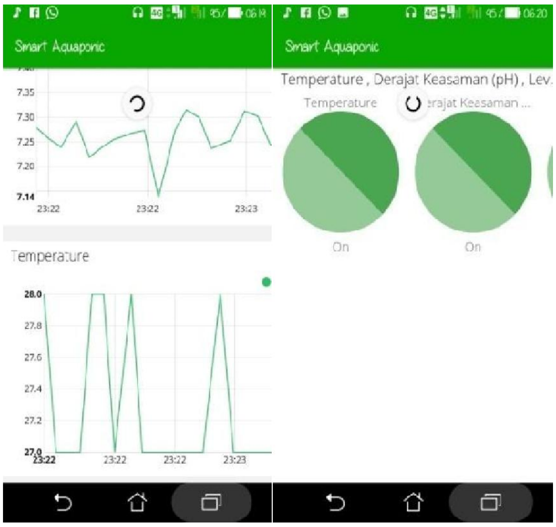

Figure 4. Android Interface

4.4. Testing of Quality of Service

The Quality of Service parameters used in this study are throughput, delay and packet loss. Of thethree parameters will be tested on each data sensor transmitted to the server via a WiFi network. Calculations are done manually by analyzing the data transmitted on the serial monitor and receivedon the server. The calculation results are compared with the categories of each parameter tested to draw conclusions on the good or bad of a monitoring system (see **Table 4**)

Table 4. Results of *Quality of Service* Testing

Sensors	Ultrasonic	pH	Temperature
Throughput (Kbps)	8.2	8.2	8.2
Index	1	1	1
Packet Loss (%)	0	0	
Index	4	4	4
Delay (ms)	2000	2000	2000
Index	1	1	1

Plant and Fish Growth

Based on Figure 13, the growth rate of lettuce is slightly slow that can be generally seen from fewoccurring leaves and the plant height also increases from 1 to 2 cm every week, and only reaches 5 cm at 4 MST (1 month) . the lettuce growth is hampered due to the influence of high temperatures on Madura Island so that many lettuce plants experience evapo-transpiration.

According to Karsono et al (2003), plant growth will be inhibited if the air temperature is high and evapo-transpiration runs continuously [12]. In addition to temperature, the factors that can influence the production of fish feces and pH of water, which are not suitable and do not meet the needs of plants. The number of leaves and plant height have increased for 4 MST even though the increase is only one strand (see figure 10). The lettuce growth can be seen in figure 5 to 8.

Figure 5. Lettuce 1 MST

Figure 6. Lettuce 2 MST

Figure 7. Lettuce 3 MST

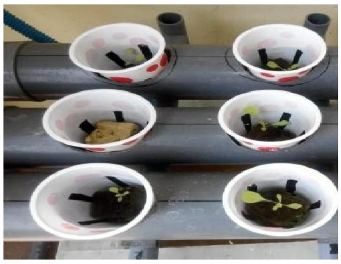

Figure 8. Lettuce 4 MST

Tilapia placed on aquaponics is those with the same average age, which is about 1 week with a dense amount of 30 tails. Feeding intensity is carried out 3 times a day (morning, afternoon, and evening). Figure 14 shows the growth of tilapia, in which the results show that the average fish growthgoes well and continues to increase every week with the length of the fish parameters increasing by around 1-2 cm per week from 1 week of maintenance (1MP). Besides, the body size of the fish always shows positive growth except the weight because of the limitations of the tool. Henceforth, the parameters used are only the length of the fish. Figure 9 to 12 portray the tilapia growth

Figure 9. Tilapia 1 MP

Figure 10. Tilapia 2 MP

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Figure 11. Nila 3 MP

Figure 12. Tilapia 4 MP

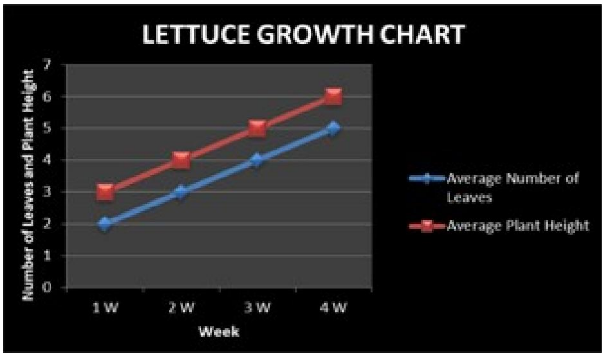

Figure 13. Lettuce Growth

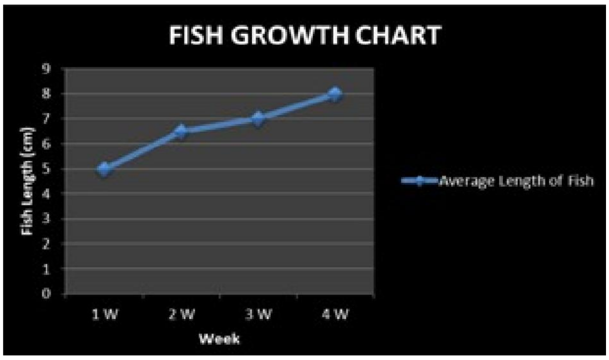

Figure 14. Tilapia Growth

Figure 15. *Smart Aquaponics System*

Figure 15. is an overview of the overall aquaponic system circuit. All components in the system design have been installed properly including fish and plants that will be cultivated in a smart aquaponic system.

V. CONCLUSION

Based on the results of testing and research conducted conclusions can be drawn that the level of accuracy of the sensors used is quite high with an average success rate of 99.943% for ultrasonic sensors, pH sensor of 92.353% and temperature of 97.907%. The process of sending and receiving sensor data to an Internet of Things based server runs well using a WiFi connection. Growth of plants and fish on the smart aquaponic system ranges from 25 oC to 30 oC and pond water pH between 7-7.5 with the intensity of fish feeding 3 times a day. The characteristics of the smart aquaponic system monitoring network system is not very good with the throughput index value is 1, packet loss 4 and delay with index 1. The suggestion for the next research is to make an adaptive aquaponic system where the system can be adjusted according to the type of crop and the appropriate nutrient needs.

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REFERENCES

[1]. N. Hari Kumar, an autonomous hydroponic system using WSN based on 6LoWPAN; Sandhya Baskaran; Sanjana Hariraj; Vaishali Krishnan, 2016 IEEE 4th Future Internet of Things and Cloud Seminar International Conference (FiCloudW) Year: 2016 | Conference Papers | Issuer: IEEE

[2]. VEGILAB and Fish Vegetable Symbiosis Indoor Growth System, July 2014, DOI: 10.1109 / SusTech.2014.7046233, Conference: 2014 IEEE Sustainability Technology Conference

[3]. Saaid of M.F. N. S. M. Fadhil, "Automatic Indoor Hydroponic Cultivation Technology", M.S.A. Megat Ali, School of EE and Technology, M.Z.H. Knoll University, MARA Shah Alam, Malaysia.

[4]. The Sultanate of Oman in 2017 to realize agricultural sustainability of solar automatic hydroponic systems, DOI: 10.1109 / ICSGSC.2017.8038547, Conference: 2017 IEEE International Conference on Smart Grids and Smart Cities (ICSGSC).

[5]. https://www.infosys.com/industries/agriculture/insights/documents/vertical-farminginformation-communication.pdf

[6]. Shafeena T Department of state computing and Engineering. Faculty of Engineering, "Smart Hydroponic System: Challenges and Opportunities", Mananthavady, Wayanad, Kerala, India. European Journal of Engineering Technology Progress, 2016, 3(2): 52-55

[7]. Smart aquaponic with monitoring and control system based on Internet of Things, Wanda Vernandhes; N.S Salahuddin; A. Kowanda; Sri Poernomo Sari2017 Second International Conference on Informatics and Computing (ICIC) Year: 2017 | Conference Paper | Publisher: IEEE

[8]. Optimizing photovoltaic system by direct cooling and transferring heat to aquaculture medium to boost aquaponics food production in needy communities, Fareed Ismail; Jasson Gryzagoridis, 2018 International Conference on the Industrial and Commercial Use of Energy (ICUE), Year: 2018 | Conference Paper | Publisher: IEEE

[9]. Design implementation of indoor farming using automated aquaponics system, M.N. Mamatha; S.N. Namratha, 2017 IEEE International Conference on Smart 32 Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM), Year: 2017 | Conference Paper | Publisher: IEEE

[10]. G. N. Murray-Tortarolo, V. J. Jaramillo and J. Larsen, "Food security and climate change: the case of rainfed maize production in Mexico", Agricultural and Forest Meteorology, vol. 253–254, pp. 124-131, 2018.

[11]. S. A. A. Abusing and B. W. Mandikiana, "Towards sustainable food production systems in Qatar: assessment of the viability of aquaponics", Global Food Security, 2020.

[12]. Z. J. Ong, A. K. Ng, and T. Y. Kyaw, "Intelligent outdoor aquaponics with automated grow lights and internet of things", Proc. IEEE International Conference on Mechatronics and Automation, pp. 1778-1783, 2019.

[13]. W. Vernandhes, N. S. Salahuddin, A. Kowanda and S. P. Sari, "Smart aquaponic with monitoring and control system based on IoT", Proc. International Conference on Informatics and Computing, pp. 1-6, 2017.

[14]. K. S. Aishwarya, M. Harish, S. Prathibhashree and K. Panimozhi, "Survey on IoT based automated aquaponics gardening approaches", Proc. International Conference on Inventive Communication and Computational Technologies, pp. 1495-1500, 2018.

[15]. A. K. Ng, Y. K. Lim, H. S. Tay, W. S. Kwang, and S. R. Hettiarachchi, "A smart recirculating aquaculture system with NI compact RIO and WSN", Proc. NI Engineering Impact Awards ASEAN/ANZ Regional Contest, pp. 24-32, 2016.

[16]. P. Serikul, N. Nakpong, and N. Nakjuatong, "Smart farm monitoring via the Blynk IoT platform: case study: humidity monitoring and data recording", Proc. International Conference on ICT and Knowledge Engineering, pp. 1-6, 2018.

[17]. J. K. Tharamuttam and A. K. Ng, "Design and development of an automatic solar tracker", Energy Procedia, vol. 143, pp. 629-634, 2017.

[18]. Divas Karimanzira and Thomas Rauschenbach, enhancing aquaponics management with IoT-based Predictive Analytics for efficient information utilization (ELSEVIER), 2019.

[19]. R Varsha, AC Santhosh, S Sowndharya, R saranish, and R Prabha, Smart Aquaponics using IoT(JETIR),vol.6,no.6,June2019