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The Implementation of Hydroponic Automation System and Monitoring Through the BLYNK Application

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Abstract

The decline in the number and conversion of agricultural land continues to occur, as shown by the increase in the number of housing and development in the industrial sector. Besides, the lack of interest from the young generation to be actively involved in agriculture is one concern in the slow development of agriculture in Indonesia. This issue can be answered by applying hydroponic systems, yet there are deficiencies in its application, such as the high maintenance and the dependence on PLN electricity. The solution offered is to combine the hydroponic system with IoT, using an Arduino Microcontroller with several sensors to read predetermined parameters, among others are Ultrasonic Sensor, DHT11 sensor, TDS meter sensor, and Voltmeter sensor. Monitoring data can be accessed through the Blynk application in real-time. Further, to reduce dependence on PLN electricity, a series of solar panels were attached to charge the available batteries. Using the research method System Development Life Cycle (SDLC) waterfall model and utilizing the Arduino IDE with the Java programming language so that tools can be formed to help users reducing production costs and increasing the interest of the young generation in agriculture in the industry 4.0.

Keywords: Arduino, NodeMCU, Blynk, hydroponics, IoT.

I. INTRODUCTION

In Industry 4.0, currently, automation and acceleration are used as the foundation (Fitriani, 2019). For instance, in the production application in the industrial sector robots have been deployed to help even replace humans in their respective work. In the past, to buy something we had to go to a store selling goods and paid directly. Now, we only need to search through smartphones and buy and pay from home. Human beings are required to be able to follow the times in all aspects of their life. Technological developments are growing rapidly, whether in the fields of industry, communication, or agriculture. However, as the development and benefits are gained, new problems may arise.

The increasing population has resulted in a decrease in agricultural land (Pambudi et al., 2018). The decreasing agricultural land is so obvious that it cannot be denied, it occurs since the increasing population results in the conversion of agricultural land to industrial and residential land (Crisnapati et al., 2017). Apart from the development of the industry, another factor that may cause the declining trend of the young generation in agriculture is the unhygienic and foul-smelling depicted by the process of cultivating the land. This decrease causes a lack of regeneration in agriculture so that Indonesia will continue depending on imported foods (Adriana Sharadhea Ningtyas, 2019).

The hydroponic system is an answer in overcoming the problem of limited hydroponic agricultural land (Ciptadi & Hardyanto, 2018). Besides being able to overcome land limitations, the hydroponic agricultural system is not limited by seasons (Mas'ud, 2009). However, the hydroponic system also has drawbacks, which are an expensive installation process and high production costs. The hydroponic plant care process requires equipment that will be helpful for farmers and can reduce maintenance costs (Furqaana, 2019). To overcome these problems, researchers attempted to design an integrated system by utilizing the concept of hydroponic agriculture and the concept of IoT.

II. LITERATURE REVIEW

Hydroponics is a farming system using planting media other than soil. The planting media may contain rock, husk charcoal, or rockwoll which are used to support the growth of plants. In nature, hydroponics only relies on water for the distribution of nutrients required by plants (Roidah, 2014). It is expected that implementing a hydroponic system, will produce better quality crops.

In this final project, the researchers used a vertical type of hydroponic or so-called Verticulture. The advantage of this arrangement is that it is more space-efficient for cultivation and does not require a lot of material to compile the arrangements (Nori Andrian, Mariati, 2018). Besides, the dripping system in irrigating plants allows roots to appear and be submerged in water so that stem rot can be avoided and plant roots obtain more oxygen intake.

According to Maria, in her research entitled "Automation of Irrigation Systems and Nutrition Based on Total Dissolve Solid (TDS) Value in Hydroponic Nutrient Film Technique

(NFT)". Hydroponic farming methods rely on water for nutrient distribution, so plant watering must be regular and continue to rely on water pumps. If plant care is not following the schedule and the time is not enough in maintenance, the plant growth might be under average or even not optimal so that the yields will be reduced (Parikesit, 2017)

Similar research entitled "Application of IoT Technology to Hydroponic Using Arduino and Blynk Android". The research discusses the hydroponic series of the NFT (Nutrient Film Technique) type which utilized Adruino Uno to read humidity and air temperature around the hydroponic circuit, regulated nutrient content levels automatically using the YS-F201 sensor, and monitored sensor readings through the Blynk application on Android (Ciptadi & Hardyanto, 2018).

Another research "Hydroponic Management and Monitoring System for an IOT Based NFT Farm Using Web Technology" implemented a control and monitoring system to facilitate website-based maintenance, using Adruino Uno, esp 8266, and Raspberry Pi 2. Furthermore, the hydroponic NFT web interface management system used a responsive web framework, such as Bootstrap for front-end libraries, JQuery, and JavaScript (Crisnapati et al., 2017).

Based on explanations from previous researches, the researchers concluded that to cover the shortcomings of the hydroponic system can be overcome by building a simple system that can reduce maintenance costs and high production costs. The researchers attempted to apply a hydroponic system combined with the use of monitoring through the Android-based application, Blynk. Blynk application was chosen because of the easy installation on the smartphone, in which users can select the appearance of the application according to their preference and the Blynk application can be accessed for free (Wahyu Adi Prayitno, Adharul Muttaqin, 2012). As an alternative power supplier, solar panel systems are used to reduce dependence on PLN electricity (Suryawinata et al., 2017). By utilizing the IoT concept in agriculture, farmers can easily monitor the agricultural condition and environment from anywhere, can control production support tools, such as irrigation pumps and nutrient regulation easily.

III. METHOD

This research used software system design methods and electronic circuits, applying the System Development Life Cycle (SDLC) or commonly known as the waterfall method since the researcher shall wait for the previous stage to be completed before proceeding to the next stage (Bassil, 2015). The method in this study consists of 5 stages:

III.I. Problem Identification

This research is based on several problems arising from the implementation of the Hydroponic System. Problems include:

a. The expensive cost to build a series of hydroponic systems with the type of NFT system and NFT system is regarded not to provide an adequate solution for space efficiency.

b. The dependency on PLN electricity and the absence of alternative power when the electricity goes off will affect the distribution of water that has been halted causing plants to wither and even, worse, die.

c. The high intensity of maintenance will result in increased production costs for the application of the hydroponic system.

d. Based on previous research, the majority only monitored one parameter, such as temperature and humidity or watering schedule.

III.II. Needs Analysis

This stage was carried out by collecting data and information about the need of the researcher in the process of making "Hydroponic Care Automation Systems and Monitoring through the Blynk Application". Besides, the researchers also conducted a needs analysis regarding software and hardware that could be possibly used to support the research process. In this study, the researchers divided the needs groups into 3 parts.

a. Hydroponic System

The needs in making a hydroponic system can be divided into 3 parts. These include the need for tools, the need for a series of frames, and the basic needs for planting. The needs are described in Table 1.

Table 1. Need Analysis of the Hydroponic System

No	Hydroponic Frame	Supporting Tools	Basic Needs of Plant
1	PVC Pipe 4" Dim	Electric Drill	Watercress Seeds
2	PVC Pipe 2" Dim	Roll Drill Bit	Rockwool
3	PVC Pipe 3/4" Dim	Glue	Seed Tray
4	PVC Pipe Cap 4" Dim	Glass Sealer	Fertilizer A/B Mix
5	Water Hose	Cloth Sandpaper	
6	"T" Connector	Cutter	
7	Box Container 20 Litre	Ruler	
8	Plastic Box Panel		

b. Microcontroller Circuit

The tools and materials required in making the microcontroller circuit are divided into 2 parts, software, and hardware. Need analysis of the microcontroller circuit is displayed in Table 2.

Table 2. Needs Analysis of Microcontroller

No	Hardware	Software
1	NodeMCU	Arduino IDE
2	Ultrasonic Sensor	*Java* SE
3	DHT 11 Sensor	Blynk Application
4	Voltmeter Sensor	Blynk Local Server Module
5	TDS meter	
6	LDR Sensor	
7	PCB Board	
8	Jumper Cable	

c. Electronic Circuit

Need analysis in making electronic circuit is divided into 2 parts, hardware, and supporting tools. The requirements are presented in Table 3 below.

Table 3. Needs Analysis of Electronic Circuit

No	Hardware	Alat Penunjang
1	Step Down DC Module	Ties Cable
2	Solar Panel	Tin Solder
3	18650 Battery	Solder
4	Relay	USB Cable
5	Submersible Water Pumps	Cable
6	Adaptor Charge	*Connector Male/Female*
7	Step UP DC Module	*Flux*

III.III. Design

In the design stage, the researchers attempted to build the system as minimal as possible. The goal is to reduce manufacturing costs and be portable. To simplify understanding, the flow of the system is shown in Figure 1.

- Start –connecting –connected? –authentication is sent to Blynk server – read sensor
- Voltmeter –battery percentage <30%.? - yes –light intensity >minimum? –charged using PLN –charged using solar panel –No –send battery percentage to Blynk application

DHT 11 –send temperature, humidity to Blynk application

- Ultrasonic –reach minimum limit –yes – send warning notification – No –send data and sensor status to Blynk application
- TDS meter –send data and sensor status to Blynk application

Figure 1. describes how the IoT system in the hydroponic method works. When the system is connected, an authentication code will be sent to the Blynk server. The connected Blynk application will receive input from the sensor that has been installed. When the sensor coming from the voltmeter shows a battery percentage <30% with a light intensity greater than the minimum limit, the voltmeter will charge either through PLN electricity or a solar panel and the sensor will send battery percentage status data to the Blynk application. If the voltmeter does not show the battery percentage <30%, the sensor will send the battery percentage status to the Blynk application. DHT 11 sensor will transmit temperature and humidity data to the Blynk application. The ultrasonic sensor is used to measure the water level by reflecting sound waves utilizing objects floating in the water, then the sensor status will be sent to the Blynk application. The sensor on the TDS Meter will send data about the concentration level of nutrients contained in water to the Blynk application.

The design stage is divided into 3 types; IOT system design, hydroponic frame design, and electronic circuit. The design types comprise:

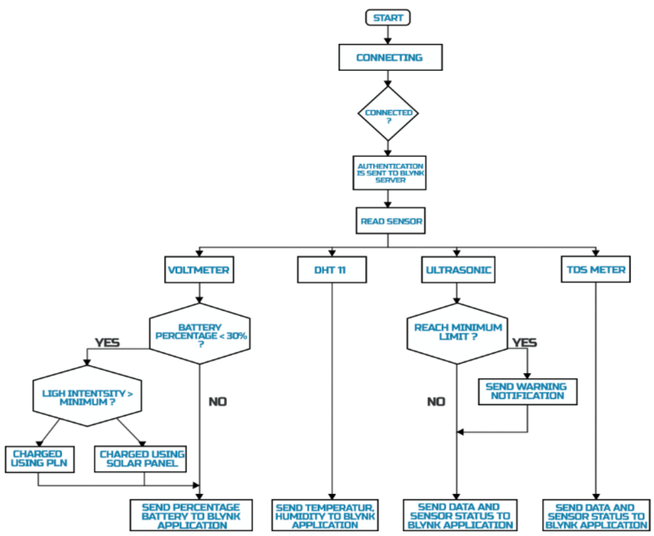

Figure 1. Flowchart of Overall System

a. IoT System Design

The IoT system design utilizes Arduino with NodeMCU board as a microcontroller to read sensors based on predetermined parameters. The Lolin V3 type NodeMCU Board was chosen because it has a small size and has been equipped with an ESP8266 type Wifi Card so it is expected that it can facilitate communication between the microcontroller and the Blynk monitoring application in displaying parameter data readings. The system design is shown in Figure 2 as follows.

-Monitoring Blynk from device –internet –Blynk server

-microcontroller unit

-distance sensor –infrared sensor –Volt meter sensor – temperature sensor – TDS Meter sensor –light sensor

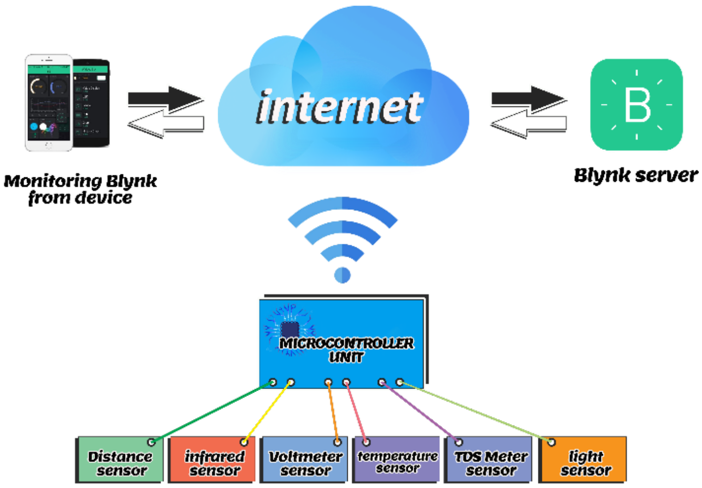

Figure 2. Microcontroller System Design

Based on Figure 2., the workflow of the IoT system in this study is that the monitoring device is the user's Smartphone and the Microcontroller must be connected to the same network as the researchers used a local server installed on the laptop. When all are connected to the same network, the Microcontroller will send data readings from the sensor to the user's Smartphone via the Blynk application.

b. Hydroponic System Design

In this study, the researchers attempted to arrange a type of hydroponic system in a vertical form to increase the efficiency of the planting space. The form of the hydroponic frame design is displayed in Figure 3.

-Solar panel –water hose –panel box –tank –water pump

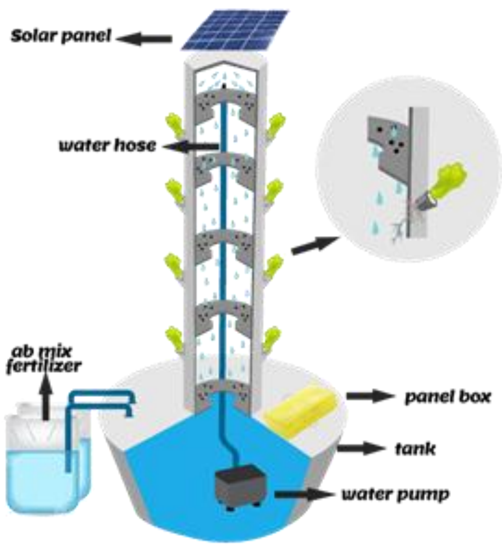

Figure 3. Vertical Hydroponic Design

c. Electronics Flow Design

At this stage, the researchers emphasized the circuit on a charging system using a solar cell system as the main energy source to power all devices. The system used for this tool consists of a solar panel, controller, battery, and a StepUp module (DC to DC). The solar panel is a module comprising several solar cells made of semiconductor silicon, which is multi-crystalline with an efficiency level of 10 ~ 13% (Crisnapati et al., 2017). The solar panel is a medium that converts direct sunlight into electricity by releasing electrons when exposed to sunlight. These electrons are used to generate DC electricity and the power must be extended because it can speed up battery charging with the StepUp module. The amount of electricity generated is measured by the Voltmeter sensor. For details, see Figure 4.

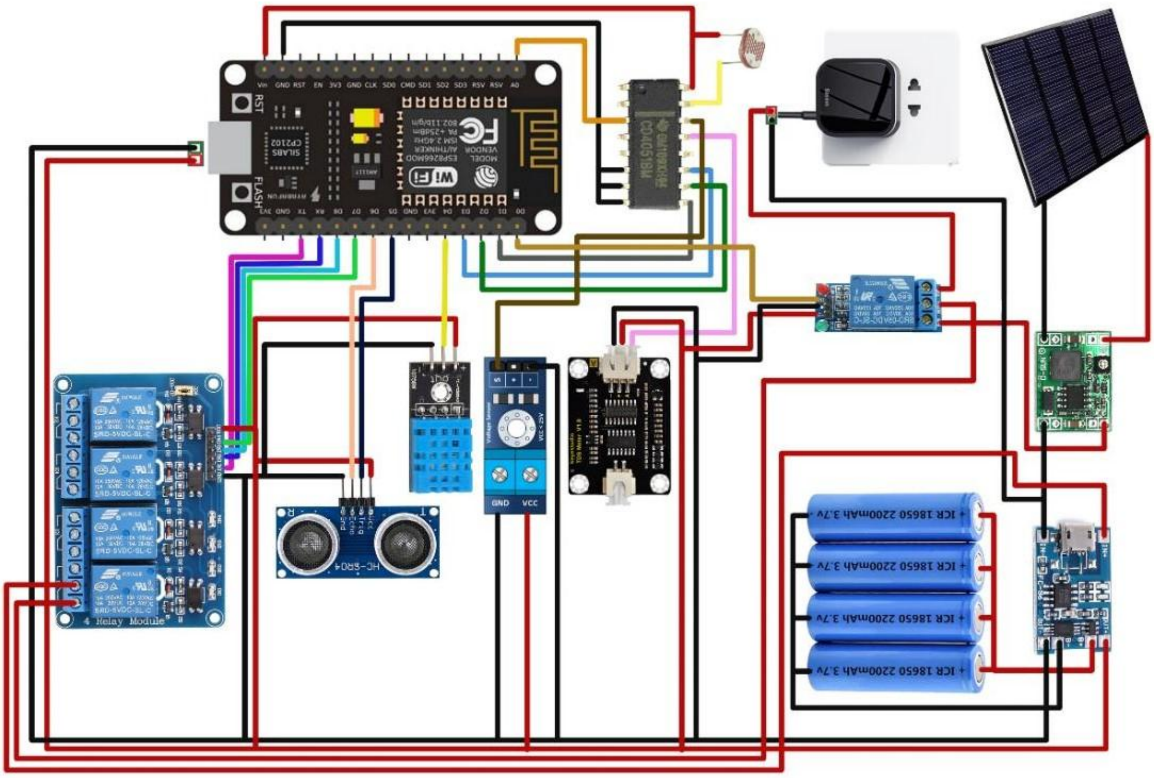

Figure 4. Wiring Diagram

III.IV. Implementation

The implementation stage is divided into 3 main parts, comprising programming Arduino, assembling hydroponic systems, and finally arranging electronic module based on built design.

a. Arduino programming

The programming process of Arduino is a step of translating the system design so that it can be understood by the machine, in this case, a microcontroller. Thus, the results of the analysis and design must be transformed into a form that can be understood by a machine, which is a programming language through the coding process (Suhendar, 2017). This stage is the implementation process of the IoT system design. At this stage, the program was divided into small modules adjusted to the sensors used and determined the environmental parameters which later be read by the sensor and then combined in the next stage. The IoT system used is Nodemcu. Nodemcu is a developer board equipped with a low-cost ESP8266 IEEE 802.11 chip with a full TCP/IP stack and microcontroller capabilities that run at 80Mhz and is attached with 128KB of memory (Rezeck, P. A. F., Azpurua, H., & Chaimowicz, 2019). Besides being affordable, Nodemcu also supports wireless connections with the IEEE 802.11 b/g/n protocol so that data communication can be directly connected to the available access points (Pamungkas & Handaga, 2019). In addition to Nodemcu, the IoT system includes a temperature sensor (DHT11), a TDS Meter sensor (DF-Robot), a Distance sensor (Ultrasonic), a light sensor (ldr), a current sensor (Voltmeter).

b. Assembling Hydroponic System

The hydroponic system assembly was completed according to the planned design. In this study, researchers built a hydroponic system with a minimal and compact circuit to be portable so that it is expected to save more costs.

c. Compiling Electronics Module

The implementation of the electronics circuits focuses on solar panel systems for alternative supply. If the predetermined parameters are not fulfilled, the sunlight will not allow it to charge the battery, so the charging system will be directed to the PLN panel. The modules required for implementation are Step Up module, charger module, solar panel board, and charger adapter. The power obtained will be stored on the battery to supply the water pump power, microcontroller, and turn on the overall sensor.

III.V. Evaluation

At the evaluation stage, the integration of each module was conducted. The modules consist of sensors on the microcontroller that had been programmed following needs and are integrated with the hydroponic system and solar panels. This stage was also carried out by testing the module's functions to find out whether the module is well-functioned or not. If the module does not meet the expected criteria, the module will be rechecked to find out the error. At this stage, researchers included the explanation in results and discussion.

IV. RESULTS AND DISCUSSION

In the part, researchers will explain the system that had been completed. This section describes the results of assembling and test data evaluation on several sensors to be compared with conventional tools that are commonly used in hydroponic.

IV.I. Research Results

The results obtained are in the form of a discussion of the results of the tools assembly and the monitoring screen display on the Blynk application, as well as the test data of several sensors to be compared with conventional tools.

a. Monitoring Screen Display

There are several data displays from sensor readings that were used as parameters, including the display of data on the temperature of the environment around the device and air humidity which was taken from the DHT 11 sensor reading data. This sensor was chosen because it uses a single write serial interface which is fast, easy process, small size sensor, low power consumption, and can transmit output within 20 meters (DHT11, 2010). Datalog display of temperature and humidity could be observed in realtime. Furthermore, there were 4 switch panels to turn on the main water pump, nutrition pump, and water filling pump from the reservoir. On the battery charging switch, there was an LED as a panel indicator as well as a relay switch indicator between charging with an adapter or solar panel. Also, there was a data display from the TDS meter sensor readings as a parameter for reading data of the nutrient water density level contained in the PPm unit. Then, there was a battery percentage indicator. Finally, there was a display of the water level taken from the ultrasonic sensor data reading. For more complete information, Figure 5 shows the display.

Figure 5. Monitoring Screen Display on Blynk Application

b. Hardware Shape and Design

Based on the wiring diagram scheme, researchers assembled the module and microcontroller in one panel. To make it more convenient for eyes, a hole PCB with a distance of 2.14mm between the holes was made. The display of the module can be seen in Figure 6.

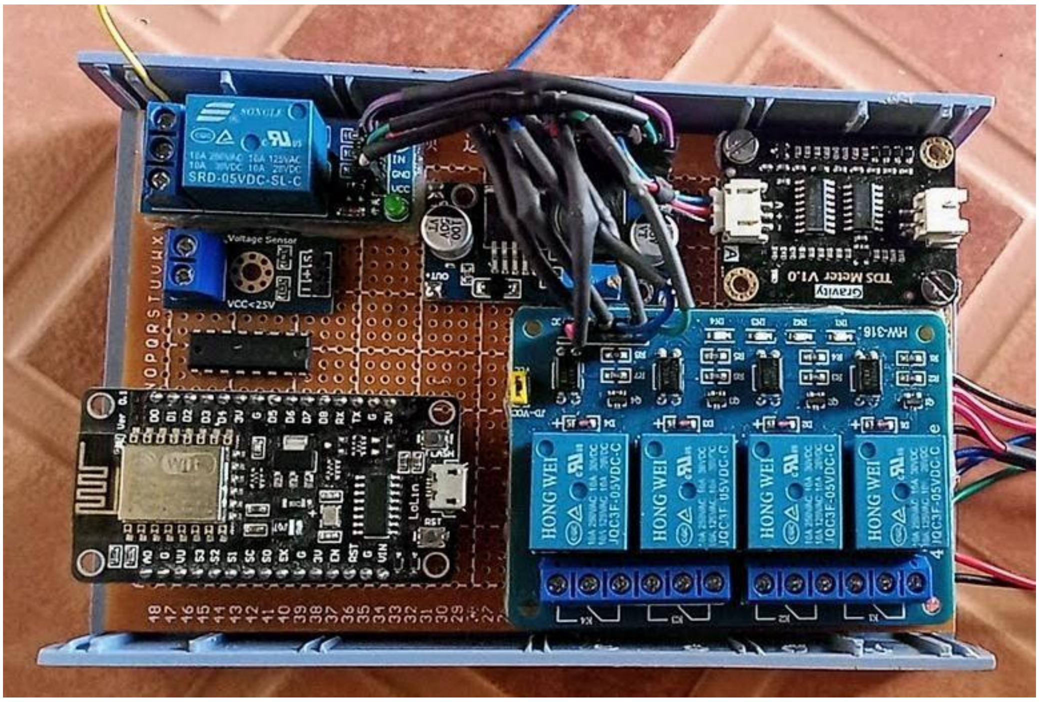

Figure 6. Hardware circuit

c. Blynk Server Local Settings

The testing and implementation stage of the tools in this research utilized a local server installed on the researchers' laptop. The local server of the Blynk application was chosen because the menu tools that can be used are various and free. For details, see Figure 7.

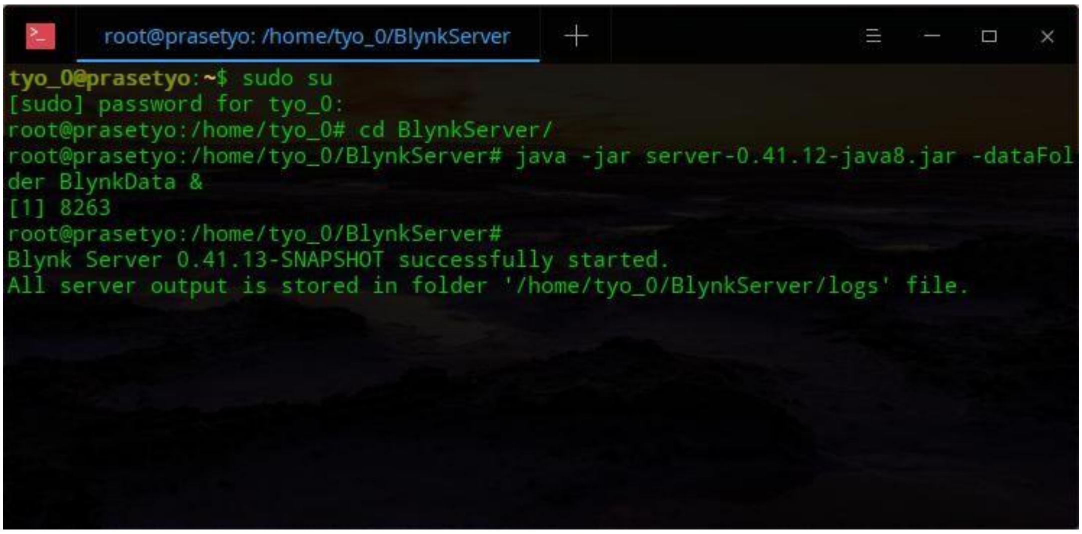

Figure 7. Running Jave SE Application and Creating Blynk Folder through Terminal

IV.II. Test Results

In this section, researchers discuss the testing of several sensors to be compared with data from conventional tools. It aims to monitor the functionality of the data generated by the sensors. Test data were taken 10 times. The sensors taken are the ultrasonic sensor, DHT 11, and TDS meter.

a. Ultrasonic Sensor Testing

The application that can be applied using the HC-SR04 sensor is a measuring device for the water level (Fikri et al., 2015). The data test is based on the calculation of the speed formula, which is speed = distance/time. The ultrasonic wave velocity is 340 m/s so that for 1 cm it takes 1/340 or 0.00294. If the distance is 1 cm (1 cm = 0.01 m), then it will take 0.01 x 0.00294 s = 0.0000294 s (29.4 µs). So, to cover a distance of 1 cm, it takes 29.4 µs x 2 = 58.8 µs. To calculate distance = travel time/58.8 (in cm) (Zhmud et al., 2018). Further information can be seen in Table 4.

Table 4. Data Testing of Ultrasonic Sensor

Testing Number	The Height of Nutrient Water	
	HC-SR04 (ultrasonic)	**Ruler**
1	5	5.5
2	6	6
3	7	7
4	8	8.2
5	9	9.5
6	10	10
7	13	12.8
8	15	15
9	17	17.5
10	20	20.3

b. TDS Meter Sensor Testing

The concentration of nutrients in solution is very influential in production plants. This is related to the number of EC (Electrical Conductivity). The EC value provides information for farmers regarding the nutrients contained in the solution and absorbed by plants (Eridani et al., 2017). The function of the TDS meter is to measure the concentration level of the nutrients.

Table 5. TDS Meter Sensor Data Testing

Testing Number	Concentration Level of Contained Nutrient (PPM)	
	TDS Meter Sensor	**TDS meter**
1	31	37
2	79	86
3	159	155
4	326	319
5	353	349
6	280	300
7	416	419
8	579	576
9	740	790
10	890	912

c. DHT Sensor Testing 11

DHT11 is a digital temperature & humidity sensor which has been calibrated to produce a digital signal. This product has high reliability and long-term stability. The DHT11 sensor has 2 output data, which are temperature and humidity (Wang & Chi, 2016). Humidity is relative to the output of a digital signal with a relative error of measuring 4% temperature and 18% humidity (Putra, 2014). In Table 6, the comparison of temperature and humidity data is described.

Table 6. DHT11 Sensor Data Testing for Temperature

Testing Number	Environment Temperature (°C)	
	DHT11 Sensor	**Thermometer**
1	23	23
2	22	22
3	25	25
4	30	29
5	33	34
6	27	27
7	24	24
8	20	21
9	21	21
10	26	26

Table 7. DHT11 Sensor Data Testing for Humidity

Testing Number	Environment Air Humidity (%)	
	DHT11 Sensor	**Hygrometer**
1	59	60
2	62	62
3	70	71
4	81	81
5	75	75
6	68	66
7	85	88
8	87	87
9	76	77
10	69	70

V. CONCLUSION AND SUGGESTION

V.I. Conclusion

Based on the research that has been done, it can be concluded that:

1) The Blynk monitoring application run as expected.
2) The Blynk application was more flexible and minimalist for monitoring use compared to the website one.
3) Applications and concepts designed could shorten the maintenance and monitoring time of hydroponic plants.
4) Able to save on electricity costs using solar panels

V.II. Suggestions

Based on the research that has been carried out, it is suggested for further development and implementation of this research that:

1) The need for tools and materials is still difficult to obtain and the costs incurred are more compared to conventional agriculture. Implementation of this research is better used on a production agricultural scale but it is possible for a home-scale production.
2) The use of existing electronic devices and sensors is recommended to be implemented in indoor farms/Green House to maintain safety and longer service life.

REFERENCE

[1] Ningtyas AS, Santosa B. Minat Pemuda Pada Pertanian Hortikultura Di Desa Kelor Kecamatan Karangmojo Kabupaten Gunungkidul. Journal of Development and Social Change. 2019 Apr;2(1):49-60.
[2] Thind S, Bidhan K. Simulation Model for the Spiral Software Development Life Cycle: A Review. Journal of Software Engineering Tools & Technology Trends. 2015 May 27;2(2):1-6.
[3] Ciptadi PW, Hardyanto RH. Penerapan Teknologi IoT pada Tanaman Hidroponik menggunakan Arduino dan Blynk Android. Jurnal Dinamika Informatika. 2018;7(2):29-40.
[4] Crisnapati PN, Wardana IN, Aryanto IK, Hermawan A. Hommons: Hydroponic management and monitoring system for an IOT based NFT farm using web technology. In2017 5th International Conference on Cyber and IT Service Management (CITSM) 2017 Aug 8 (pp. 1-6). IEEE.
[5] DHT11 D. Temperature Sensor DHT 11 Humidity & Temperature Sensor. Datasheet. 2010.
[6] Eridani D, Wardhani O, Widianto ED. Designing and implementing the arduino-based nutrition feeding automation system of a prototype scaled nutrient film technique (NFT) hydroponics using total dissolved solids (TDS) sensor. In2017 4th International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE) 2017 Oct 18 (pp. 170-175). IEEE.
[7] Fikri R, Lapanporo BP, Jumarang MI. Rancang Bangun Sistem Monitoring Ketinggian Permukaan Air Menggunakan Mikrokontroler ATMEGA328P Berbasis Web Service. POSITRON. 2015 Nov;5(2).
[8] Fitriani Y.D., Abdul A. Literasi Era Revolusi Industri 4 . 0. Senasbasa. 2019:100–104.
[9] Furqaana IF. Irrigation Scheduling Untuk Tanaman Selada Hidroponik Dengan Metode Nft Menggunakan Arduino.
[10] Mas' ud H. Sistem hidroponik dengan nutrisi dan media tanam berbeda terhadap pertumbuhan dan hasil selada. Media Litbang Sulteng. 2009 Dec;2(2).
[11] Andrian N, Sitepu FE. Pertumbuhan dan Produksi Bawang Merah (Allium ascalonicum L.) pada Pemberian Hidrogel dan Frekuensi Penyiraman dengan Sistem Vertikultur: Growth and Production of Shallot (Allium ascalonicum L.) on Hydrogel Application and Watering Frequency with Verticulture System. Jurnal Online Agroekoteknologi. 2018 Apr 17;6(2):286-93.
[12] Pambudi WR. Prototipe Sistem Pemeliharaan Otomatis Pada Pertanian Hidroponik Menggunakan Metode Aeroponik (Doctoral dissertation, Universitas Muhammadiyah Surakarta).
[13] Pamungkas RB, Handaga B. Sistem Monitoring Keadaan Ruang Laboratorium Fakultas Komunikasi dan Informatika di Universitas Muhammadiyah Surakarta. Emitor: Jurnal Teknik Elektro. 2019 Sep 10;19(2):66-73.
[14] Parikesit MA, Yuliati S, Angka PR, Gunadi A, Joewono A, Sitepu R. Otomatisasi sistem irigasi dan pemberian kadar nutrisi berdasarkan nilai Total Dissolve Solid (TDS) pada hidroponik Nutrient Film Technique (NFT). Widya Teknik. 2019 Jul 27;17(2):70-8.
[15] Putra SA, Supriyono H. Jurnal Emitor Vol.16 No. 02 ISSN 1411-8890. Sistem Informasi Pengelolaan Service Toko Komputer Berbasis Qrcode. 2014;16(02): 23–30.
[16] Zajc LČ, Rezelj A, Skočaj D. Teaching with Open- Source Robotic Manipulator. InInternational Conference on Robotics and Education RiE 2017 2018 Apr 18 (pp. 189-198). Springer, Cham.
[17] Roidah IS. Pemanfaatan lahan dengan menggunakan sistem hidroponik. Jurnal Bonorowo. 2015 Jun 25;1(2):43-9.
[18] Suhendar AK. SISTEM PAKAR DIAGNOSA KERUSAKAN MESIN ROBOT TAKE OUT MENGGUNAKAN METODE FORWARD CHAINING DAN PENELUSURAN DEPTH FIRST SEARCH (STUDI KASUS: PT. DYNAPLAST). Jurnal Ilmiah Fakultas Teknik LIMIT'S Vol. 2020;16(1).
[19] Suryawinata H, Purwanti D, Sunardiyo S. Sistem Monitoring pada Panel Surya Menggunakan Data logger Berbasis ATmega 328 dan Real Time Clock DS1307. Jurnal Teknik Elektro. 2017;9(1):30-6.
[20] Wang Y, Chi Z. System of wireless temperature and humidity monitoring based on Arduino Uno Platform. In2016 Sixth International Conference on Instrumentation & Measurement, Computer, Communication and Control (IMCCC) 2016 Jul 21 (pp. 770-773). IEEE.
[21] Zhmud VA, Kondratiev NO, Kuznetsov KA, Trubin VG, Dimitrov LV. Application of ultrasonic sensor for measuring distances in robotics. InJournal of Physics: Conference Series 2018 (Vol. 1015, No. 3, p. 032189).