Hommons: Hydroponic Management and Monitoring System for an IOT Based NFT Farm Using Web Technology

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***Abstract*— The significant decrease in agricultural land and the rapid development of hydroponic system technology such as Nutrient Film Technique (NFT), have brought huge challenge to farmers. This hydroponic system requires special attention to several parameters such as the water temperature, water level, acidity (pH), and the concentration of the nutrient (EC/PPM). We first monitor and collect information from NFT Hydroponic farmer and then systematically evaluate and analyze them. Unfortunately, it is still controlled by using the conventional way (human), for example in controlling the concentrations of nutrient has to be done at least once a day, so much time is wasted. In addressing these issues, we need a system that can be applied and used easily. We built a hydroponic monitoring and automation system that can monitored using sensors connected to the Arduino Uno microcontrollerm, Wi-Fi module ESP8266 and Raspberry Pi 2 Model B microcomputers as the webserver with the concept Internet of Things, in which each block hydroponic farming can communicate with the webserver (broker). Web used as the interface of the system that allows user to monitor and control the NFT hydroponic farming. The NFT hydroponic web interface management systems using a responsive web framework, such as Bootstrap for the front-end, JQuery and JavaScript libraries. The result shows that this system helps farmers to increase the effectivity and efficiency on monitoring and controlling NFT Hydroponic Farm.**

Keywords—IoT; Internet of Things; NFT Hydroponic Farm; Arduino Uno; Raspberry Pi; single board computers; microcontrollers

I. INTRODUCTION

Agricultural lands are already declining in Indonesia even in the world. This happens due to the conversion of agricultural land into industry and settlement purpose. This happens because of economic and social phenomena, the limitation of land resources, population growth and economic growth [1]. Currently, agricultural technology developed rapidly in urban areas, it is often called urban farming or urban agriculture. Urban farming or urban agriculture is one powerful solution to cope the dwindling agricultural land. The urban agriculture using the unused or empty land in urban areas, such as rooftops, balconies, terraces, even on the walls of buildings. One of the farming techniques used on urban farming is hydroponics. This year, some hydroponic farming techniques are becoming popular in urban agriculture practices. Hydroponic cultivation was planted by utilizing water and do not use soil as medium of its planting with emphasis on the needs fulfilment of nutrients for the plants. Hydroponics is derived from Greece, hydro meaning water and ponous means work. [2]

The hydroponics technique has many compact types and it can overcome the land problems in urban areas, one of them is the NFT (Nutrient Film Technique) that can be arranged vertically. In hydroponic farming system, the water will be used continuously and just diminishes because of evaporation by the Sun or by the photosynthesis process of plants. If it is compared to conventional agriculture, water is used once at the time of irrigation, this system can be said to be very wasteful in the use of water because a lot of water is wasted. In this hydroponic system required particular care in controlling water temperature, water level, acidity (pH) of the nutrient solution, and higher densities of nutrient solution [3]. The control process still uses the conventional way or still using human power in doing so, for example, in controlling the density level of the nutrient solution is performed at least once a day which if the density of nutrients is too high or too low then add water or nutrients where farmers or owners of hydroponic farming system sometimes spent much time. This becomes a problem which is quite important because it is not effective and less efficient.

This paper focused on creating a hydroponic farm management system that could monitor water temperature, water level, higher densities of nutrient solution and the acidity (pH) of a nutrient solution using sensors are related and connected to the microcontroller via a website. Hydroponic farming management system allows the user to perform control and monitor from a distance. The green energy concepts used in the Hommons. The alternative energy source is the sun which was used by utilizing solar panels to convert into Electricity.

Associated with this research, previously there have been several studies related to hydroponics and automation in agricultural systems. The first study is a study carried out by Usman Ahmad, Dewa Made Subrata, and Chusnul Arif in 2011, entitled "Speaking Plant Approach for Automatic fertigation System in Greenhouse" is about fertigation system (system of irrigation water and plant nutrients) that runs automatically at a greenhouse. In this study, the amount of water and nutrients are distributed to fit the needs and circumstances of the plant, the plant conditions will be observed using a CCD camera that is connected to the image processing. Plant growth, which in this study using a tomato plant, will be observed. Plants will be photographed by the CCD camera every three days and then will be analyzed height by a program that has been developed. The results of this analysis will be used as input for fertigation systems are already automated to turn on and turn off the pump to deliver water and nutrients to plants [4].

Research on hydroponic farming system that has automated also conducted by J. R. N. Felizardo, A. D. B. Halili, and J. N. S. Payuyao entitled "Automated Hydroponics System with pH and Temperature Control". In journals or research, hydroponic farming system has been able to measure the pH level and temperature according to the type of plants to be grown. The level of acidity (pH) is regulated is the pH of the nutrient solution. If the system detects a nutrient solution is too acidic or too alkaline for the plants then the system will automatically balance. For temperature, there are two sensors to be mounted on the mixing tank and the place of investment. In addition, in this system there is also a GSM module that serves to send text messages to the owner of the plant if a nutrient solution or water runs out, and there are also an LCD that serves as an indicator of the level of pH and temperature [5].

II. Experimental

Solar cell system used as a main source of energy to turn on all the devices. Solar system used for this tool consists of a solar cell panel, controllers, battery (battery) and inverters (DC to AC). A solar panel is a module that consists of several solar cells made from silicon semiconductor material namely Multicrystalline wich has 10 ~ 13% efficiency. These solar panels are combined in series and parallel with 20 Watts power capacity. Solar panels as a medium that convert sunlight directly into electricity by releasing elekron when exposed by sunlight. This elekron used to generate DC electricity and must be converted to AC with an inverter. The amount of electricity generated is measured with inverter watt (W). In general the design of the power source with solar cell system is shown as Figure 1 below:

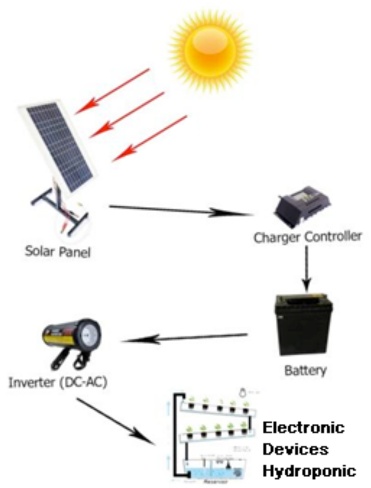


Fig 1. Power Suply

Calculation of the electrical consumption used in the system done by summing the total wattage load. The total power is calculated in units of Watt/hours that used every hour. Here are the calculations that have been done.

TABLE I. Energy Consumption

No	Name	Total	Time (Hour)	Capasity (Watt)	Total
1	Reservoir Pump	1	24	60	1440 Wh
2	Water Box Pump	1	1	25	25 Wh
3	Nutrition Box Pump	4	0.25	5	5 Wh
4	Water Pump	1	24	2.5	60 Wh
5	LED	1	12	12	224 Wh
6	Mikrokontroller + sensors and actuator	1	24	10	240 Wh
7	Microcomputer + Wi-Fi	1	24	24	240 Wh

Figure 2 shows the general system workflow of hommons that describes the process flow delivery or data requests.

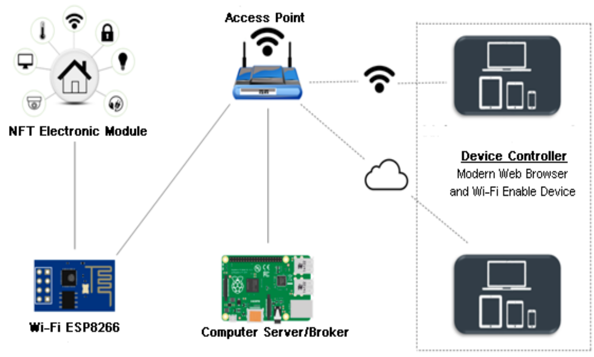


Fig. 2. Hydroponic Monitoring and Management System Flow

Fig. 2 describes each object can communicate with the server/broker based on the address that already set before. Every object equipped with ESP8266 module as a communication medium through a wireless network to the internet. Using wireless networking communication media provides the system advantages such as can be integrated with other objects – objects that have connection to the internet. Systems that have been connected to the network can be accessed through the web page using browser based on the server address. The next step, comes the authentication page where asked to login before user can access the main page. Webserver/broker can submit a request or receiving a response from the module objects. Requests that are sent will be processed in accordance to the specified function when there is a response, it will be received and stored then shown into a web page..

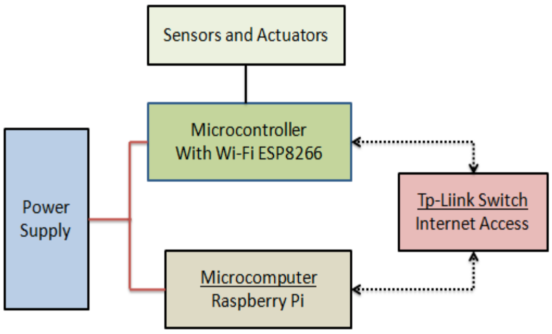


Fig. 3. Hydroponic Monitoring and Management System Hardware Design

Figure 3 describes the Hommons hardware design relationship of the NFT which consists of sensors, actuator, microcontroller, ESP8266, wi-fi access point, microcomputer Raspberry Pi and power supply. Microcomputers which served to accommodate the webserver and brokers. Microcomputers used are Raspberry Pi 2 Model B ARM Cortex-A7 architecture. Communication technologies on this system using 802.11 or better known as Wi-Fi by using the internet. The power supply using voltage 5V 2A, this voltage is the standard voltage and easy to find on any device that is compatible with the USB power supply. Various environmental sensors installed to detect any change in the physical or chemical environments. This component is very important on a NFT system implementation. Changes in value that occur in the environment will be read by the sensors and will become the input to the process management of NFT.

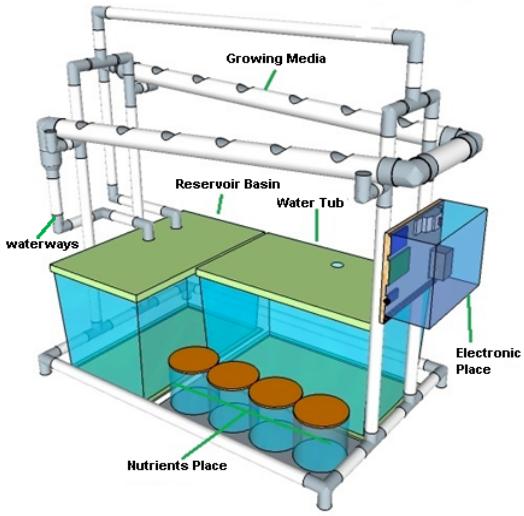


Fig. 4. Hydroponic Monitoring and Management Physical Design

The physical design created in order to make it easier to put the components. The physical form of the NFT hydroponic farm management system, designed as shown in Figure 4. The core material of the PVC pipe tool with size 3 dim as his planting medium and ¾ dim PVC to flow the nutrient solution. The reservoir using a plastic box which serves to accommodate any mix of nutrient solution in water

III. Results and Discussions

After the user successfully performs the login process so the system will redirect the user to the main page heading, as shown in Figure 8. This page is divided into several sections, namely, main content, sidebar and navbar. The sidebar on this page is the main menu of the NFT hydroponic farm management system. There are 2 buttons on the sidebar navigation, i.e. home and settings. On the main content there are 4 columns that display data from the sensors-sensors on the NFT hydroponic farming tools, such as nutrient levels, nutrient pH levels, temperature, nutrient and nutrient EC & PPM level. These data will assist the user in NFT hydroponic farming systems qualify. In the navbar on this page there are two buttons, namely notification and system settings. The notification function button to display the alarm or warning to the user if there is something on the system while the system settings button function to set the system (restart & shutdown) and logout of the system.

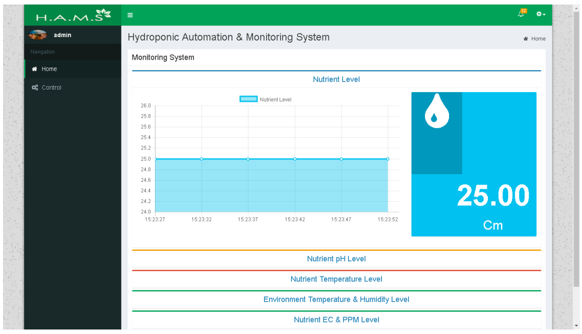


Fig 5. Hydroponic Monitoring and Management Webpage.

Automation settings pages are divided into two parts: first part with its own set of pH and PPM values are desirable way entering the value in the textbox that is available as Figure 6. The second automation page contains a selection of plants type which pH and PPM value have been set before so farmers only need to choose the type of plants that they manted to grown. Automatic setting is already contained the value of pH and PPM that have been set previously by the system so that new farmers no need to worry by the value that should be worn on his planting media, they can choose this setting to make it easier as shown in Figure 7.

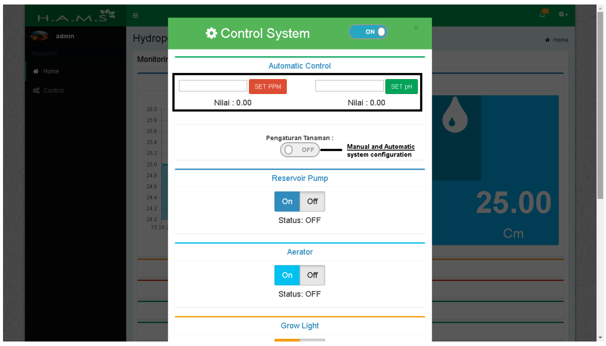


Fig 6. Automation Configuration Page 1

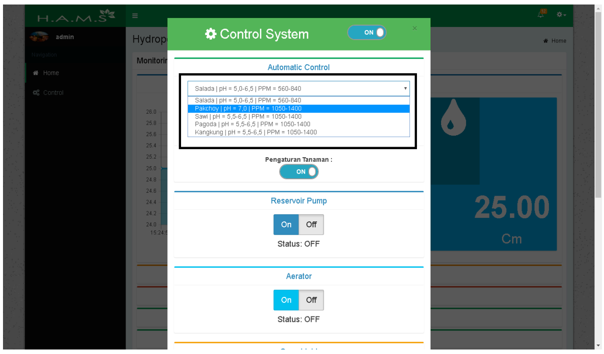


Fig 7. Automation Configuration Page 2

The end result of the system of agricultural manajamen hydroponics NFT has modern this research can be seen in the pictures below, beginning from Fig. 8which is the front view of the NFT hydroponic farm management system.

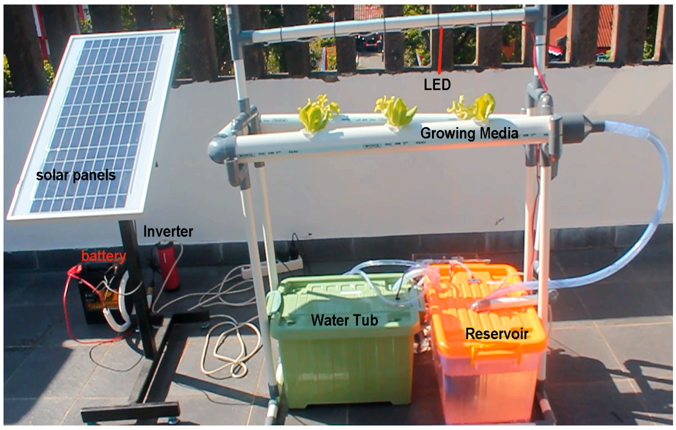


Fig 8. Tampilan Alat Pertanian Hidroponik

In Figure 8 shows the hydroponic NFT management system (Hommons). The overall dimensions of the hydroponic management and monitoring system is 90 cm × 45 cm × 120 cm. In Figure 7 can be seen the NFT hydroponic farming tool consists of 2 PVC pipe 2.5 dim with a length of 80 cm have been modified. On each there are 3 holes with net pot diameter, distance of 17 cm for each hole that was used as a place to put the net pot. The electronic device is shown in Figure 9.

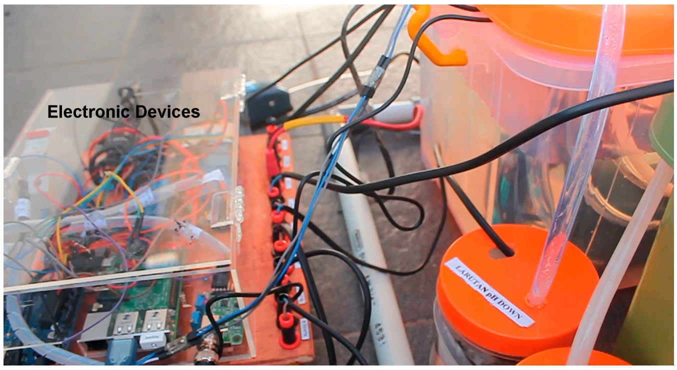


Fig 9. Electronic Devices

After the hardware (sensors) on the hydroponic NFT management system integrated, sensors need to be tested to quantify the level of accuracy. This test includes testing of Ultrasonic sensors, pH, temperature, and the EC. The results of these tests can be seen in table II, III, IV, V.

TABLE II. HEIGHT SENSOR TEST RESULT

Testing Number	Nutrient Solution Height (cm)	
	HC-SR04 (Ultrasonic)	***Ruler***
1	7	6
2	7	6
3	7	6
4	9	9

Testing Number	Nutrient Solution Height (cm)	
	HC-SR04 (Ultrasonic)	*Ruler*
5	9	9
6	8	9
7	9	9,5
8	10	9,5
9	10	9,5
10	10	9,5

TABLE III. PH SENSOR TEST RESULT

Testing Number	pH Nutrient Solution	
	pH Sensor	*pH Meter*
1	6,70	6,8
2	6,76	6,9
3	6,57	6,9
4	6,78	6,9
5	7,0	7,0
6	6,97	7,0
7	7,27	7,1
8	6,95	7,1
9	7,11	7,1
10	7,14	7,2

TABLE IV. TEMPERATURE SENSOR TEST RESULT

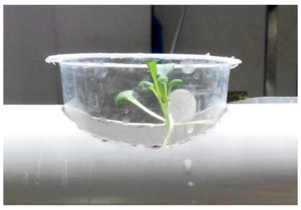
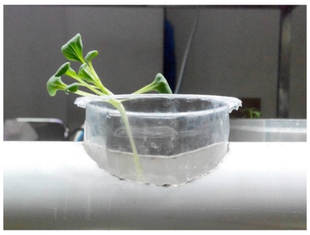
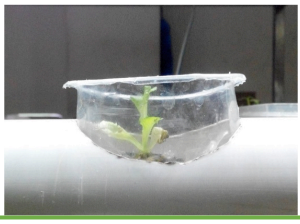
Testing Number	Nutrient Solution Temperature (°C)	
	DS18B20 (Temperature Sensor)	*TDS Meter*
1	26,8	27,0
2	26,8	26,9
3	26,7	26,9
4	26,5	26,5
5	26,3	26,3
6	26,3	26,4
7	26,3	26,4
8	26,2	26,4
9	26,2	26,4
10	26,2	26,3

TABLE V. EC SENSOR TEST RESULT

Testing Number	Nutrient Solution EC	
	EC Sensor (EC / PPM)	*TDS Meter (EC / PPM)*
1	0,71 / 357	0,42 / 300
2	0,71 / 357	0,42 / 300
3	0,70 / 350	0,42 / 300
4	0,70 / 350	0,42 / 300
5	1,70 / 848	1,18 / 830
6	1,70 / 848	1,19 / 839
7	1,82 / 910	1,20 / 841
8	1,82 / 910	1,20 / 841
9	1,77 / 884	1,19 / 838
10	1,76 / 880	1,20 / 842

The system testing using the original plant samples to find out if the plant is growing well. Testing was conducted using several different types of plants with the same treatment. The plants used in this test is pokchoy, lettuce, and kale at the teen age period (after nursery). Testing is done by observing the growth of plants for a few days. Plant growth was observed by taking pictures of the plant as shown in table VI.

TABLE VI. TESTING RESULT USING PLANTS ON HOMMONS

No.	Observation	Information
1		The first observations on pakcoy plants, plant pakcoy seen growth slowly issuing new leaf segments.
2		In the second observation, the plants grow taller pokchoy visible and visible leaf segments increases and slightly enlarged.
3		The first observations on lettuce, lettuce plants grow slowly visible on the leaf segment that looks wide.

IV. Conclusions And Future Work

This research focused on creating a system that can help farmers or owners of hydroponic farming system in caring for or create a hydroponic farming system by using a hardware module that is easily found in the market with a relatively affordable price. This system is made for agricultural management systems hydroponics NFT using the Arduino Uno microcontroller and microcomputers Raspberry Pi 2 Model B as well as using web technologies as the interface is responsive. The Arduino Microcontroller Uno combined with various sensor-related sensors such as Ultrasonic sensors SR04-HC, pH sensor, DS18B20 temperature sensor, the sensor and the EC as well as the supporting tools to create farm hydroponics NFT like, grow light, water pumps, and aerator. Raspberry Microcomputers Pi 2 Model B in this system serves as a place to store server/web interface, the settings of the supporting tools (water pump, aerator, grow light), and the data obtained by the sensor-sensor after it is processed by a microcontroller.

The web interface on the hydroponic monitoring and management system can control and monitor agricultural systems hydroponics NFT responsive and designed for its users. The web interface is built using a front-end framework Bootstrap combined with HTML, JavaScript, and PHP. This system can be implemented at the NFT hydroponic farming and can optimize the plant growth. It can be seen from the observation result table of the plants.

The future work of this research is to collect environmental data, wich obtained from sensors and implanting an artificial intelligence that makes the Hydroponic Management and Monitoring System can run otomatically.

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