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DESIGNING OF URBAN FARMING SYSTEMS BASED ON INTERNET OF THINGS

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ABSTRACT

Purpose of this study is to find out whether the design of information systems can help agricultural industrial processes, to find out how the use of IoT in agricultural industrial processes, and to find out how the design of an IoT-based information system can monitor plant status. System design using the Arduino Wemos D1 Microcontroller. The design of IoT and sensor designs and other schemes uses Axure as a medium for making prototype designs. UML design and flow diagrams using Visual Paradigm. Implementing the cloud as a medium of communication between the IoT concept and the system to be created. The benefits of the systems such as : Assist users in controlling plant maintenance both during planting and harvesting, Can make it easier for users to find out the status of the plant and the room temperature to keep it stable, and Can be expanded and developed into a product that can be used by the wider community in the urban agricultural industry

Keywords: *urban farming, systems, IOT, designing*

1. INTRODUCTION

Technology has a great impact on the development of the digitalization era, the use of technology is not only used by the general public. In this case, many industries have implemented the use of technology that can help each process and the running of industrial activities, one of which is Agriculture or the agricultural industry. Agricultural commodities are one of the important aspects in meeting the needs of food supply in Indonesia. And in recent years, one of the concepts created in agricultural commodities in the middle of big cities or known as urban farming is increasingly in demand by people who live in big cities. Urban agriculture is oriented towards realizing the convenience of fulfilling daily food needs and creating additional urban green open spaces. Agricultural commodities in the middle of urban areas requires regular or certain continuity of the process. On the other hand, urban agriculture creates a good impact on the environment, especially providing additional green open space, but this commodity has a significant problem in price fluctuations that often occur in the Indonesian market, due to the influence of climate change that occurs in Indonesia, increasingly facing extreme weather and anomalous weather. The existence of this causes a change in the cycle of planting, and the harvest period is unexpected. It will affect the process that occurs, where the negative impact of Urban Farming is if it is not done properly and optimally which causes an increase in noise and air pollution, flooding and a waste of energy, especially water. Various problems that arise can be overcome by using the application of IOT-based technology (micro-climate monitoring automation technology). It is of the technologies that can be used to ensure the development and cultivation process runs well and produces good quality and quantity. IoT can allow objects or objects to be controlled remotely using the internet network and online media, and of course, the application of IOT itself in the urban agricultural industry can provide many advantages, the capabilities that can be generated are various, for example in sharing data , being a remote control, and many others that make every process run without the need for human labor as a whole. In this context, IOT can help track plant care in each season, provide estimates in the form of sensors that can detect temperature, and other things related to the success of harvests in this agricultural industry. With technological developments, especially in the field of information technology, through the use of the application of IoT by using a system of objects or plants, it can be monitored and can indirectly communicate with one another via the internet network. The application of IoT itself has run quite a lot in everyday life and is widely used in various industrial applications such as animal farming, which is a tool that can feed livestock automatically, smart power plugs that can adjust electric current using a timer and many other things. again. Passing this stage, several simulations will be carried out related to the procedure for implementing IoT micro-climate monitoring in the structure of the planting process at Urban Farming. The first stage is to develop technology in collecting monitoring data on temperature, humidity, and light to obtain energy sources in the process of development. In the next stage, it will enter and be developed into making machine learning-based systems that will help in controlling intelligent automation at plant planting sites. The purpose of this application is that later machine learning can provide information based on information on temperature, humidity, light and automatic watering which is determined through the use of IoT to provide maximum support and results. In connection with the above, to be able to create and help increase the processing of the agricultural industry from the side of Urban Farming with the application of the Internet of Things (IoT) which can make it easier to monitor the overall status of plants, track planting history, and automatic watering of plants.

2. RELATED WORKS

A. Micro-Climate Agriculture

Micro-climate is a set of climatic conditions measured in a localized area near the earth's surface including temperature, light, wind speed, and humidity which can provide meaningful indicators for habitat selection and other ecological activities [1]. Chen et al., (1999) explain that the micro-climate has become an important component of current ecological research because it greatly influences ecological processes such as plant regeneration and growth, soil respiration, nutrient cycling, and selection of wildlife habitat. Micro-climate is very closely related to habitat and is important for organisms at the micro scale [3]. Light intensity, soil moisture, soil temperature, air temperature, soil acidity, wind direction and CO2 levels are micro climatic factors that are very influential in cultivation productivity. These factors can be controlled artificially to maximize productivity and quality of crop cultivation.

B. The Hydroponics Techniques

There are many planting techniques in agriculture. One of the most popular in today's society is the hydroponic technique. Hydroponics is a planting technique using planting media other than soil, such as pumice, gravel, sand, coconut fiber or foam and utilizes water flow to provide plant nutritional needs. This makes planting does not require large tracts of land [4].

Literally, hydroponics comes from the word Hydro which means water, and Phonic which means workmanship. So that in general, it can be concluded as a system of agricultural culture without using soil, but using water mixed with nutritional fluids to meet the adequacy of plant nutrients. In its application, hydroponics is usually not only done by replacing the planting media, but also by adjusting the planting environment. The adjustment in question is by creating a planting environment such as a greenhouse, providing paranet in places with high-intensity sunlight, or adding LED's to spaces that lack sunlight. No need for large tracts of land makes hydroponics a reliable way of increasing agricultural output, especially in large cities that do not have large tracts of land.

C. Urban Farming Concept

The concept of agriculture in big cities (urban communities) is commonly called Urban Farming. Urban Farming itself is synonymous with farming patterns that use space as efficiently as possible. Examples of planting techniques that are often used are vertical planting (vertical farming), hydroponics, aeroponics and so on.

D. Internet-of-Things (IoT) and IoT-based Agriculture

IoT is a physical and virtual network of objects, such as vehicles and household devices that are able to collect data around and communicate via the Internet [5], [6]. The term IoT itself was first introduced by Kevin Ashton, co-founder of the Auto-ID Center at MIT in 1999. IoT can be considered as an evolution of the Internet today where every object can communicate with one another on a computer network. IoT extends internet connectivity beyond the common standard devices on the Internet, such as desktops, laptops, smartphones, and tablets to various everyday devices and objects. IoT devices can generally be monitored and controlled remotely. The application of IoT technology itself is very broad both at the consumer, commercial, industrial and military levels. Smart home automation, elderly care, health, medicine, transportation, manufacturing, smart cities, energy management, environmental care, and agriculture are all areas that IoT technology has generally applied.

In the modern era that always demands the automation process, IoT is no longer only used in the field of informatics. Utilization of IoT has penetrated almost in all fields, ranging from economics, business, education to agriculture. IoT makes human intervention in a process minimal and efficient. In the field of agriculture itself, IoT is commonly used in the purposes of monitoring the agricultural environment, collecting plant health data and managing crop damage risk [7]. IoT contributes significantly to modern agriculture. Farmers use IoT to control agricultural activities in a more effective way [8]

E. Microcontroller

Microcontroller is a chip that functions to control electronic circuits and store logic or programs in it. Generally, Microcontrollers consist of a Central Processing Unit (CPU), Random Access Memory (RAM), storage memory, Input or Output pins and convert analog signals to digital or vice versa. Examples of the most popular microcontrollers today are Arduino microcontrollers, Raspberry Pi, AVRA ATMega series and others.

F. Arduino Mega and Wifi Module ESP8266

Arduino is a company that creates open-source hardware and software in the form of a single-board microcontroller. Popular products produced include Arduino Uno, Arduino Leonardo and Arduino Mega. Each product is differentiated based on memory capacity, CPU speed and the amount of I / O available. In this research, Arduino that will be used is Arduino Mega.

Arduino Mega is a microcontroller board based on ATmega2560 architecture. This type of Arduino has 54 I / O pins and 16 MHz CPU clockspeed. The large number of I / O pins on the Arduino Mega allows the microcontroller to be integrated with many sensors and actuators. One of the modules that can be used together with Arduino Mega is Wifi Shield ESP 8266. This module is a module that allows Arduino to connect to the internet network, so that the process of monitoring sensor data and commands for actuators can be run from anywhere via the internet.

G. Related research

In recent years, IoT technology has increasingly been implemented in the depths of automated modern agriculture [9]–[12]. Alipio et al., (2017) developed an intelligent hydroponics system in automating crop cultivation using Bayesian Network techniques, sensors and actuators installed at the cultivation site to control light intensity, soil acid content, water temperature and humidity. They succeeded in increasing the quantity of production 66.67% higher than using manual control.

Carrasquilla-Batista et al, (2016) integrated IoT into cucumber cultivation in a greenhouse. Their design consists of electronic circuits, sensors, actuator communication devices and software that runs on cloud computing. Their system can carefully provide a large recommendation of appropriate cultivation action variables.

In research by Jayaraman et al., (2016), SmartFarmNet was developed to be able to integrate all types of IoT devices such as cameras, weather stations, sensors and others. SmartFarmNet then collects all this data into a database in the cloud for cultivation analysis and recommendations. Meanwhile, Kamilaris et al., (2016) also proposed a smart agricultural application framework, called Agri-IoT, which can support various types of IoT devices. Agri-IoT integrates types of agricultural data flows that often differ from one another.

Research in [13] discusses the integration of IoT into an agricultural process which was later given the name CLUeFarm. Research also proves how the use of IoT can make the agricultural process more efficient. Research by [14], tested plant growth when using LEDs to present power saving solutions for agriculture in confined spaces. The LEDs used have different wavelengths ranging from 510nm, 610nm and 660nm. The study also tested the effect of these wavelengths on crop yield and growth. Research that has focused on explaining hydroponic growing techniques and how these techniques can be utilized to realize agriculture on limited land has also been carried out by [4], which produces an automation system to control environmental variables that were previously uncontrollable. The data generated is then recorded using the ThinkSpeak platform. Meanwhile, research by [15] produce an optimal monitoring system using the concept of IoT on Brassica Chinensis (Pok Coy) plants. But until now there has not been much attention in Indonesia in developing intelligent systems for microclimate cultivation of horticultural crops in Indonesia. Therefore, in our research, we developed an intelligent micro-climate agriculture monitoring system based on Internet-of-Things (IoT).

3. RESEARCH METHODOLOGY

The Research Methodology can be shown in figure 1 below :

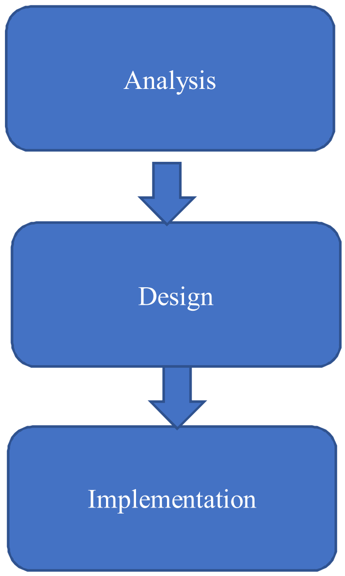

Figure 1. Research Methodology

In this study, we used three stages, such as : analysis stage, design stage, and implementation stage. In analysis stage we analyze what is the user requirement. In the design stage, we design the system using Object Oriented Analysis and Design. Architectural design will also be made based on the establishment of an API and the UI design process using AXURE RP as a medium for making and developing mockups. In the implementation stage, we create prototyping system.

4. RESULT AND DISCUSSION

In the systematic design of the urban plant monitoring process based on IoT, some descriptions are needed for making process diagrams that occur and are used to provide information about how the system process will run according to planning which is divided into several UML designs, along with Mockup designs that will be developed using the Axure tools. The design management is based on several processes that have been planned where the plant will be monitored using a microcontroller end device through some data that will also be received using sensors installed in the microcontroller unit. Among other things, the use of sensors that will be used is to take data from the PH of water, temperature, air temperature or humidity and soil moisture conditions. This method aims to provide information related to acquisition data obtained from the MCU sensor, and several things that need to be considered in installing the MCU at the design stage. The system design will also add features that allow each user to activate Smart Farming, namely that the system will automatically be tasked with caring, watering, and monitoring every process of plant growth automatically. In the application of an IoT-based plant monitoring system, the system will be based on a mobile application with the aim of making it easier for every plant. process of monitoring and recording information based on plant data. The function of using this application itself will be used to receive data and present the data that has been received through the database. Class diagram is a domain that is used to describe a class in a system where this will affect and provide information related to class architecture that can be used for design to the development stage. The following is an illustration of the class diagram used in the context of implementing the Urban Farming design, as follows :

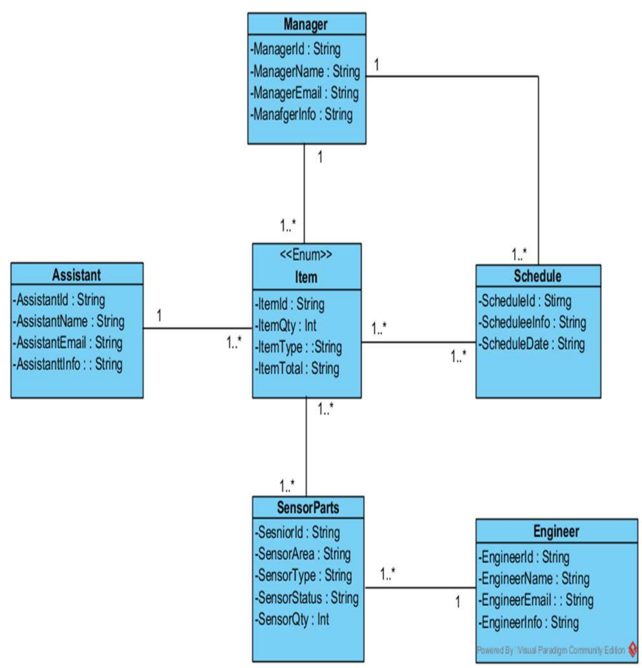

Figure 2. Domain Class Diagram

The following is an overview of Database Design which is part of the process in explaining the details of the database model, some descriptions of using this model are to avoid redundancy in data, and the following is an overview of the database design of this design, as follows;

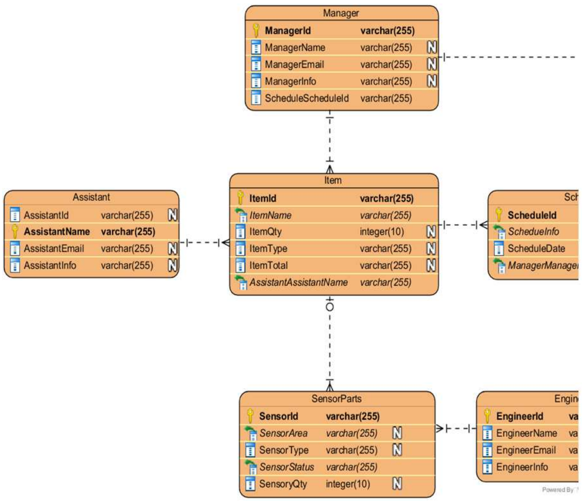

Figure 3. Database Design

The System Sequence Diagram is one of the models used to describe the process flow that occurs between a number of subjects and an object that describes an interaction between actors and the system, the following are some SSD descriptions of urban farming system design, namely as follows :

1) SSD Registers : is an illustration of the registration process of all users who enter the application to do data input so that it is verified by the server and can become an account
2) SSD Login : is a picture of the activity that occurs between the user and the system when logging into the menu, automatically all users will enter if the data system is verified and in accordance with the registration data, when entering the home menu, the user will become a certain garden manager who can take care of the garden.
3) SSD Adds Plant Info : is a picture of the manager's activity in adding information related to plant status, this feature is only available to managers because some information can be input by owners or stakeholders who have the right to add new plant information. Information that can be entered is in the form of plant information, plant descriptions, names, and standard pH levels and good lighting for plants
4) SSD Performs Plant Scheduling : is part of the activity that explains the plant scheduling process, where the user can enter the scheduling of planting, of course the attached planting information data still has to be run manually in the planting process, but status information can be changed in realtime without having to record again. Each user is also able to see the progress of the crop schedule or harvest schedule.
5) SSD Performs Scheduled Watering : describes the activity process in scheduling watering. Users can use this feature in determining the watering process both from the hour and day as well as how long it will take the integrated watering to the server and signals will be sent to the sensors and actuators.
6) SSD Check crop status : describes the activity in checking the status of plants, where each user can see the status information related to the status of plant information that is found from the sensor and processed into certain information indicators that state information on plant status.
7) SSD Set automation of crop status update schedule : describes the activities of how the process of managing the update schedule automation, where the user can schedule the sensors to provide information on plant status updates according to a predetermined schedule.
8) SSD Checking Plant Scheduling : is a description of the activity in checking plant scheduling, where the user can see the schedule that has been made. This scheduling also displays certain information such as the status of the schedule, whether it is running, finished or not.
9) SSD Perform Add Account : is an activity that describes the process of adding an account, where this feature is only available for managers who can add assistant or engineer accounts by searching the search user section as needed.

10) SSD Accepts Planting Schedule : is an activity in receiving a planting schedule in the form of a notification found by the assistant where a response can be made whether it has received and has run the given schedule
11) SSD Receive plant information data : describes the process of activities in receiving data information displayed through notifications where this can provide information to other users about the status and information of new plants
12) SSD Create Report Form : describes activities in making report forms, this feature is provided specifically for assistants in making reports in the form of status, problems, and management results which will be notified to the manager
13) SSD Schedule auto SS and record cameras : is an illustration of the activity of scheduling camera records and screenshots, where the user can schedule the recording according to the schedule conditions to be selected, besides being able to monitor via surveillance cameras, this feature will make monitoring easier
14) SSD Performs Manual Record : is a description of the activities in manual recording which is carried out to run the recording or screenshot without having to schedule it first.
15) SSD Choosing Smart Farming Features: is a description of the activity in choosing the smartfarming feature that allows users to run every monitoring, maintenance, watering and status info will be run with a system that will automatically provide recording data after the smartfarming process is run
16) SSD Choose Another Farm : describes the activity in choosing another garden where all users can supervise and manage more than 1 garden where this has a good effect on increasing association and connections for each farm owner to help each other and manage their respective gardens. In this feature the manager can become an assistant or engineer in the garden of other users according to the needs and abilities of each user.
17) SSD Install Sensor and Connect Server : explain the activities in installing sensors and connecting servers, where this process will be carried out by the engineer in meeting the needs of other users and adding stock sensors manually, besides that this process can be connected using the sensor checking feature where the engineer can enter the selected sensor information and will try to connect.
18) SSD Checks the sensor status : describes the process of checking the status of the sensor that has been made, where this status will be transparent to the engineer and the engineer will see the potential signal and whether the status process has been successfully connected and can be used or other management is still needed

Architectural system design used in describing the systematics of the architectural process, here the user will get information and make updates through the use of the API which will later be processed into data that can be read with cloud server media and will be sent to the database and send to the sensor systems. In this study, we proposed several user interface design to support the system. There are various functionality to accommodate interaction between user and systems.
The following figures shows the user interface design of the systems:

Figure 4. UI For Engineer

Figure 4 is an illustration of the appearance of the actor's home menu as an engineer, where this actor can add sensors manually in addition to system-based sensor areas which will later be connected through the server and will be checked through the sensor checker feature whether the signal and connection are connected from the server to the mobile device. Engineers also have several features that are owned by the manager with the aim of checking the feasibility and running of the system properly or not.

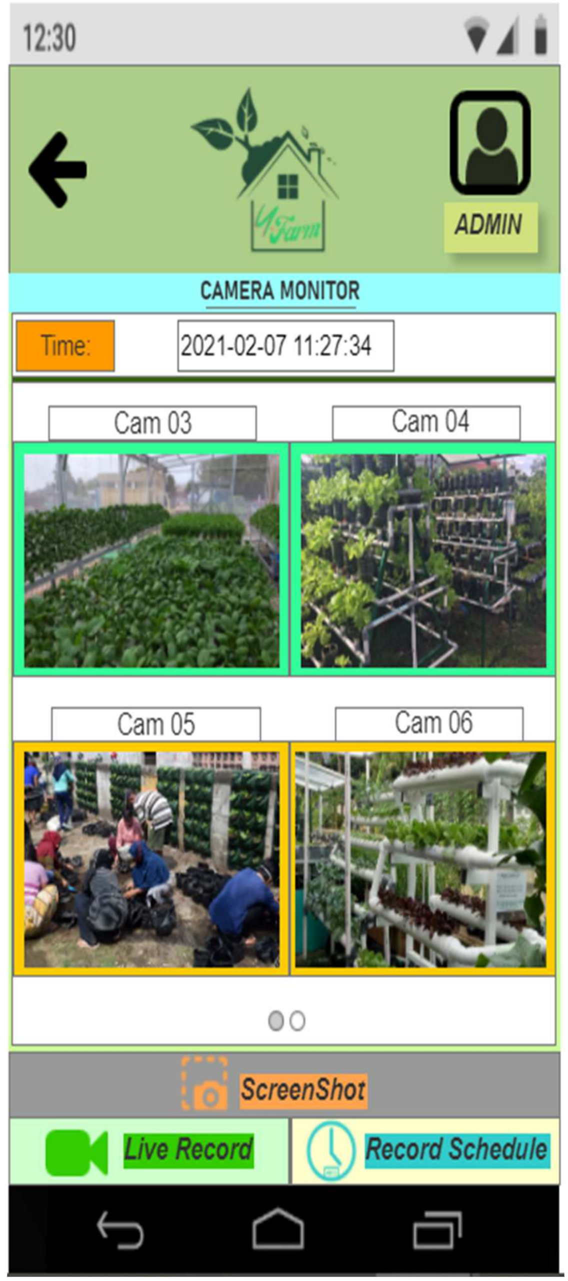

Figure 5. UI For Camera Security

Figure 5 displays the security camera feature where the user can view and monitor every activity or record manually, the user can also record automatically by setting a recording schedule in one day, so the system can automatically capture images and record all monitors according to schedule and predetermined duration.

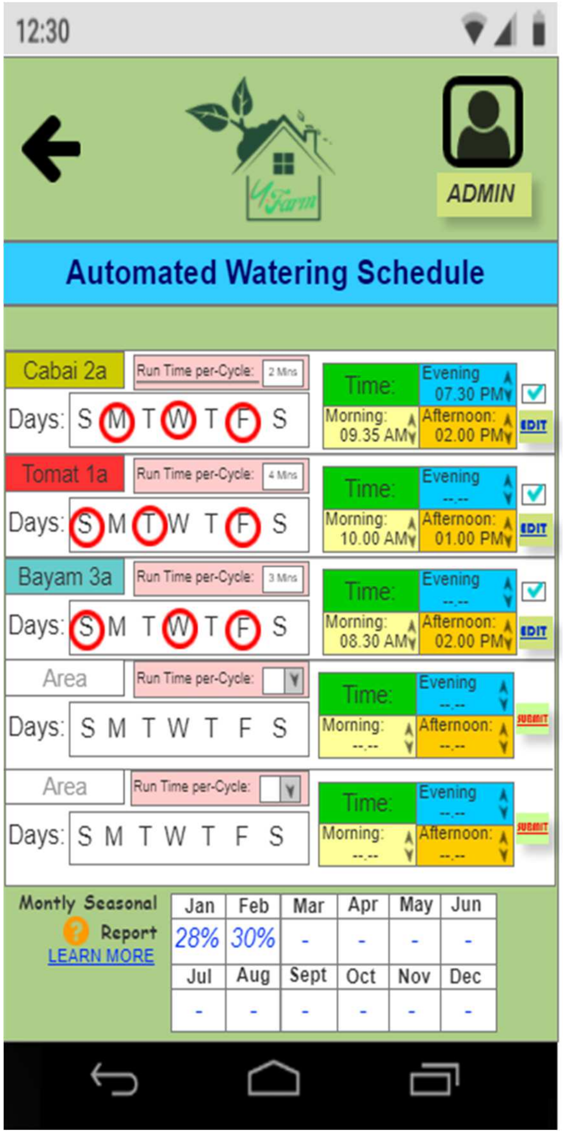

Figure 6. UI For Watering Schedule

Figure 6 is an illustration of the watering scheduling feature, where the user can use this feature to set and adjust the schedule according to a predetermined time and day area, each watering duration can also be set and each month the sensor provides overall information about water usage from a total of 1 month

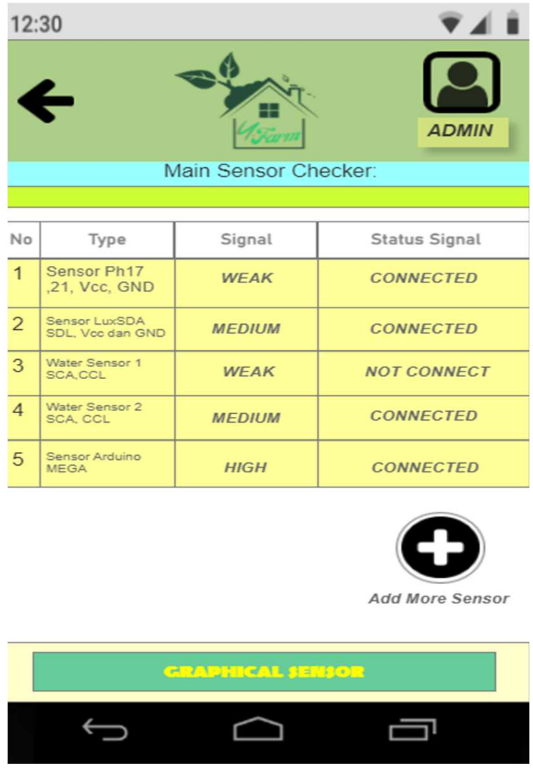

Figure 7. UI For Sensor Checkers

Figure 7 is a description of the additional features of the engineer to find out the condition and status of a sensor that is installed and used to run certain sensors later, this stage must of course run after the sensor installation process in a predetermined area.

By knowing the problems that have been analyzed using the design process on IOT-based information systems with Mobile Service media as a process of using software in the agricultural industry process, Urban Farming. Several conditions were found with conclusions that have been identified in advance, namely as follows; a) The process used in recording the development of plants that are being checked periodically will cause difficulties in finding files that have accumulated and also the large amount of paper used, plant recording also includes recording the development of plant status that has been monitored, this will certainly take some time because the number of areas that should also be thoroughly monitored and recorded. By using this IoT system, each user or user can easily check periodically using only a smartphone, data from

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plant development status information can also be monitored through the cctv media provided by one of these features, sensors will also automatically provide status to the server will be sent directly to the user. b) The next process, which includes planting activities, also has constraints in terms of weather conditions in Indonesia which are very uncertain. This affects the quality and process of plant development which is found to be unsuitable. By implementing this iot system, each plant will be given a sensor along with a temperature controller which will automatically provide information on the status of existing plants, another process is that the plant status can be accepted by the user transparently and quickly so that the user can find out which plants require special care and some. other things that have a good influence in the process of plant care. c) The next obstacle is the limitation of knowledge on how to check and determine the pH of water, soil moisture, and certain plant conditions. With the application of a system that is designed automatically the sensors will provide information related to the water pH, soil moisture, and other information based on easy-to-understand indicators, where certain indicators can easily be understood so that users can use the designed system easily. Apart from the status that is easy to read and understand, other processes such as scheduling watering and planting can be easily managed using the system created.

5. CONCLUSION

The conclusion from the analysis and design of the IoT-based urban farming system in monitoring and conducting smart farming with the system is as follows;

The design is carried out in the background of an indication of the problems that occur when planting traditionally and manually, this causes many other effects such as a waste of resources, and can result in pollution that pollutes the environment. With the IoT-based urban farming design using mobile media apps, it is possible to make it easier for users to manage and monitor via a mobile website in real time. With the IoT-based monitoring system that has been designed in each process of applying plants, it can be used effectively to increase information obtained and use in using water resources. The design is also carried out on the basis of analysis using the SDLC model which is divided into 3 stages, namely the Planning, Analysis, Design method. With the aim of being able to form any design information and analysis in detail and easily understood by every reader. From the results of the design that has been successfully made, it can be developed to the development stage and implemented in order to assist the implementation of each garden owner, especially the owner of urban farming.

Based on the results obtained through the analysis and design of an IoT-based information system for urban agriculture (Urban Farming), there are several suggestions proposed to researchers who want to develop with similar system elements, namely as follows: o The design of the system is related to the monitoring of the IoT-based system that has been made in the design stage, where other researchers can carry out the development and implementation process so that the designs made can be realized and used in the community as a tool in monitoring every process of plant development. o The current system design is still not at the maximum stage, so further development can be made more detailed and perfect by exploring data retrieval so that the data obtained is much more accurate by using the interview method, observation and several other methods in obtaining more accurate data . o It is hoped that the next researcher or design development can add an anti-pest sensor feature, which can detect pests that are in the plant environment to increase safety for future plant development.

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