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IOT BASED LOW-COST PLATFORM FOR SMART ORNAMENTAL PLANT MONITORING SYSTEM

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ABSTRACT

While integrating IoT tools with low-cost devices becomes a new challenge, many smart ornamental plant based platforms have emerged and offer innovative solutions for the automation of the ornamental plant care sector. One of the issues in making IoT tools is that the tools are expensive, have no information system, and do not get an assessment to use. To answer this issue, make a smart oriental plants platform called Garnus and test it in real-time with several scenarios in housing in Indonesia, carried out in the period April 2021 to September 2021. Experiments were carried out based on requirements to be carried out in suitability of tools, real-time monitoring, water automation, observing information systems for a long time, testing tools using BlackBox and conducting an assessment of the Website. GARNUS testing in environmental monitoring using sensors below and above the ground. The GARNUS system functions to monitor soil moisture, ambient temperature and monitor water content by installing sensor installations. after that, the sensor data obtained are collected and stored on the GARNUS Website for analysis and storage. To increase the maintenance of expensive ornamental plants. The test results show compatibility with caladium ornamental plants. The system is tested with BlackBox, and The website system has been tested with UEQ (User Experience Questionnaire), which shows good results. This action of GARNUS helps nurse ornamental plants, which greatly increases the productivity of ornamental plants and is very well used by users.

Keywords: *Smart Ornamental Plant, IoT, Low-Cost, GARNUS*

1. INTRODUCTION

With the times, the Internet of Things has been used to help humans work by minimizing human intervention. Objects in the Internet of Things are subjects or objects that are used to monitor, measure, or calculate. Therefore, the Internet of Things concept will most likely be used in all daily work and simplify manual work in the future [1]–[3].

Internet of Things (IoT) [4]–[6] is also an instrument that we often hear ourselves, both in offices, education, industry, etc. Using IoT technology has become a necessity today, which is always accompanied by advances in communication technology. Communication is needed in IoT, including measurement of delay, speed, reliability, etc. The first-generation offered is 1G, wherein there are still not many users this generation, but it is the fastest in its era. Ten years later, the second generation of 2G is reinvented, some of which can interact with the internet [7]–[9].

The city of Bandung in Indonesia is a valley area like a large lake, so mountains surround it. On the other hand, many offices demand that we use IoT [10], [11] for the necessities of life and society. Existing plants can thrive if planted in Bandung's native soil, but not for hanging ornamental plants. The need for regular watering and fertilizers makes residential areas a field for outsiders to look for in the monitoring system of ornamental plants.

In implementing IoT in ornamental plant monitoring facilities, the authors need to pay attention to several things: caution, routine watering, checking ambient temperature, keeping distance, and limiting visitors. According to a previous survey, 46.4% of people expect the platform to help in the care of ornamental plants [12]–[15]. With the times, digital applications have been used in all aspects to help humans work by minimizing human intervention. Objects in the Website application using a IoT are subjects or

objects used to monitor, measure, or calculate [16]–[18]

In the growth of ornamental plants, nutrient monitoring plays an important role. Soil moisture is one of the factors that affect nutrients [19]. Soil moisture determines whether plants easily absorb nutrients. The lack of awareness of ornamental plant managers has also caused damage to these plants.

The current issue is the lack of automation tools to monitor, analyze, and maintain ornamental plants. The fact that everyone's activities have changed at the beginning of 2020, one of which is making the hobby of planting a way to get rid of boredom. One solution is an IoT tool to automate the monitoring, maintenance and analysis of ornamental plants. But this issue has not been resolved with IoT instruments which are expensive and not easily available. Issue returns when an adequate information system does not accompany automation tools. Information systems are usually used to view monitoring results from the soil, humidity, pH, etc. Usually use the Website to see the results of monitoring, but the Website needs to be evaluated to find out whether the Website can be used according to user needs [20].

In previous studies, automation was rarely carried out with low-cost instruments and detailed information results using the Website. Usually, automation applications use single-use blynk (have to pay more if you have a lot), Research using rain sensors, and rear using the low-cost component. The function of the rain sensor is if the ornamental plants have excess water or lack of water can be anticipated. Then the evaluation in previous studies has not used a suitable scheme such as using the User Experience Questionnaire (UEQ). In this study, changes were made, one of which was adding a rain sensor, monitoring applications using the Website and evaluating the Website using UEQ [21].

IoT control in this study Smart Ornamental Plants called GARNUS (Garden Binus) system website application can also monitor soil, humidity, pH, and other sensors [22]. Lately, to test users, they usually use an evaluation of user experience (UX) because it is very important for website service users on ornamental plant care to get the best service. The interest in UX knowledge may be because HCI researchers are well aware of the limitations of conventional wisdom, focusing primarily on users and user performance. Issues with ornamental plant automation and concerns about websites that are not suitable by users can be solved in this study [23], [24].

After several issues can be solved in this Research, the author will also create a website system that can already recognize the sensors that will be used directly. This study aims to characterize the properties that must be advanced based on the results of the UX assessment using UEQ. This study can lead other website owners as a direct lead to doing a UX investigation of their own Website to decide which parts to move. [25], [26].

The author intends to conduct design research by making a GARNUS intelligent system prototype based on low-cost instruments. The function of this system is to monitor soil moisture, humidity, water automation, and install sensors. Sensors work around the plant to provide good accuracy and transmit data to the GARNUS site System application. In this way, it can automatically assist users in making soil fertilization decisions, providing information on water volume, temperature, soil moisture and real-time information. Lastly, using UEQ to assess the Website [27].

2. LITERATURE REVIEW

The IoT's ability to communicate with each other makes IoT applicable in all fields. For agriculture, loT is usually used for sensors to monitor soil conditions, temperature, and humidity. The framework of loT is clear with the way it works alludes to (three) primary instruments within the loT design, specifically Physical goods equipped. Connections of devices to the internet, such as modems and routers without wires, are as fast as at home, and website data centres are ideal places to store platforms and databases [28].

Everyone has a high demand for automation technology, and many societies are starting to implement automation [29]. Not as it had crucial needs that have been mechanized, but side interest has to be mechanized. The creation of automation has been made as in the Research [2]. In this study, automation of the aquarium was used the fish rearing process could be greatly assisted.

Authors in [30] proposed several devices that decide water is required for plants by anticipating precipitation employing a Genetic Algorithm (GA).

Authors in [20] developed an intelligent watering approach based on the combined Wireless Sensor Network (WSN) collaboration for plant monitoring. The main objective of this approach is for effective data collection and implementation of algorithms.

The author in [31] takes an applied approach to water irrigation. The system takes an approach to measuring the physical parameters of the water content. This application is associated to a few sensors within the field like; water level sensors, rice temperature sensors, and field weather stations. Network measurements show a maximum transmission distance of 11 m with a 90% success rate.

Previously Research [10] used a raspberry pi controller as an intermediary for the automation of student absenteeism and assisted by facial recognition. Therefore, the use of automation is widespread and a natural thing. Arduino for house plants has also been carried out by [32] by using the GARNUS website System as an access aid. The following is a summary table from previous studies:

Tabel 1. Literature Review

No	Ref	Conclusion	Comparison
1.	[19]	The success rate of watering plants reaches 93.75% with the tests that have been carried out	Focusing on watering plants instead of ornamental plants, hydroponics, etc.
2.	[33]	The instrument works well hardware and software can communicate with android	• Using Arduino Uno Atmega328 microcontroller. • Exchange data using BlueTooth. • Not using MCU nodes yet
3.	[32]	The prototype runs when the temperature or soil moisture decreases to turn on the water pump. Using blynk sederhana simple controls	•Focus on watering plants. Using only the Blynk app
4	[34]	Based on these results, a technically automated system. This can reduce the wastage of water for irrigation	Focusing on VANET communication only

No	Ref	Conclusion	Comparison
5	[35]	This paper presents a item to form domestic planting exceptionally simple and convenient. Users are exhorted of the leading plants to sow for their zone at that time of year	This paper only focuses on the kitchen area
6	[36]	With a real-time automatic watering system, very helpful. Therefore, this paper assumes that this approach will help our farmers through mechanizatio n of the agricultural sector	The paper focuses on how to plant outside, not for offices
7	[37]	Line Administratio n in Non-Tertiary Clinics for Moved forward Healthcare Benefit Conveyance to Outpatients.	Website in the Health sector uses a web-based system.
8	[38]	An IoT Smart Queue Management System with Real-Time Queue Tracking	The use of a micro-controller in queue management as a patient queue information center.
9	[39]	Hospital Service Queue Management System With Wireless Approach	application of Queuing theory and lean thinking to reduce patient waiting time

According to previous Research [39], an excellent queuing microcontroller system can increase patient satisfaction, which is designed in this study to use a web-based queuing system that can be used in health clinics to improve services. Subsequent Research [38] applies micro-controller technology as a patient queue information center in real-time

In 2015, the proliferation of new technologies that entered Indonesia made all lines change, and digital businesses began to form with the help of 4G internet-based technology. Until 2017 the introduction of the diversity of microcontrollers connected to the internet has not become a trend, until 2019 where the startup era has mushroomed, until 2020 there was a pandemic, the growth of internet technology needs, mainly ornamental plant hobbies, appeared in early 2020 until now [40]–[43].

After looking at some of the Research in table 1, the author of this study uses all the studies attached and applied in Bandung city. Hence, the

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paper points to executing a framework that occasionally collects information utilizing sensors on ranches and sends them to the portal; then, the gotten information is transmitted to the Website for capacity, analysis, and monitoring of ornamental plants. The proposed IoT is based on exploratory work to satisfy the necessities of robotized and real-time observing of the natural parameters for five months and must be low-cost. In this way, a clear picture can be gotten to create astute choices in overseeing the crop and improving its efficiency. realize the paper's point, the taking after inquires about destinations got to be sought if:

• O1. Identification of parameters and tools that affect ornamental plant care and monitoring

• O2. Implementation of the proposed Website and testing in the care and monitoring of ornamental plants;.

3. METHODOLOGY

This section presents the prices of so-called low-cost sensors and tools, which aim to provide information for IoT smart agriculture. The table below shows the price of a broad view of the proposed architecture.

Tabel 2. Low Cost Price Instrument

Component	Rupiah	USD
Soil Moisture Sensor	Rp 10.000	$0.7
Water Selenoid	Rp 27.000	$1.89
Temperature Sensor	Rp 20.000	$1.4
Relay 12v	Rp 3.700	$0,26
ESP 32	Rp 86.000	$6.03
16X2 LCD	Rp 28.500	$2
Arduino	Rp 120.000	$ 8.42
Rain Sensor	Rp 4.000	$0.28
Water pump	Rp 10.000	$0.70
Monitoring website	Rp 800.000	$56.11
	Total	$77.79

Table 2 shows that the need to make a smart IoT monitoring tool for ornamental plants is very cheap for IoT monitoring ornamental plants because it uses simple instruments that can be purchased and made yourself for only $76.39. The highest price is website monitoring because we have to rent hosting and domains for one year. It's still cheap because its use is one year. In this study using the prototype model method to create equipment and platform that are integrated with the Website, here is a picture of the model [28]:

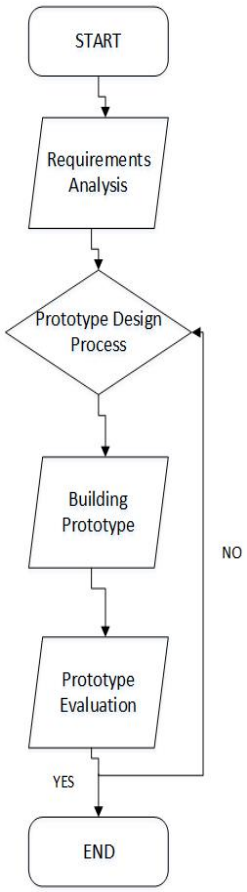

Figure 1. Prototype Model

The taking after are the stages of creating a model show:

a. Requirements Analysis

Analyzing prerequisites could be a stage where clients and engineers affirm with each other to choose on the definition of platforms and websites to see the system requirements that will be made with researchers [35].

b. Prototype Design Process

In this phase, the process is carried out where researchers carry out designs and designs that are tailored to the wishes of the User [44].

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c. Building Prototype

In this phase, the analyst makes a model or beginning test that has begun to create plans from the gadget and will be specifically connected to the device.

d. Prototype Evaluation

In this phase, researchers focus on evaluating instrument s and websites. The results of software design represented by websites and instruments are directly applied to the environment around Bandung. Evaluation will focus on instruments built to suit the User's wishes [45], [46].

1. Ornamental Plant

This study conducted trials on ornamental plants that are very popular in Indonesia, namely Caladium plants. Caladiums are tropical perennials with colourful, heart-shaped takes off local to tropical timberlands in South and Central America that have articulated damp and dry seasons. Caladium bicolour, a Brazilian species, is the foremost common of a few species in this class within the arum family (Araceae) that are utilized as ornamentals. There are thousands of named cultivars of this species.

Figure 2. Caladium Ornamental Plants [47]

2. Use case

To carry out maintenance on caladium ornamental plants, the author makes use case Diagram of the Garden Binus System:

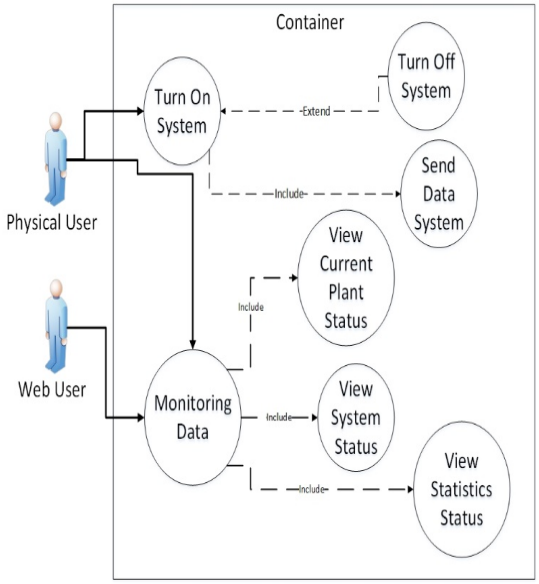

Figure 3. Diagram Use Case

Physical User: system interaction via Arduino

- Monitoring: the device has an LCD that contains updated sensor data
- Turn on/off system: Physical User can turn on or turn off the system

Web/Apps User: system interaction via Website

- Monitoring: dashboard on the web allows users to be able to read the state of the plant status

Monitoring is also useful if the User is not at home and wants to see the soil condition. The Website System can be used as real-time remote monitoring.

3. Flowchart of using IoT Low-Cost GARNUS

At this stage, the stages of use will be explained based on hardware and based on users.

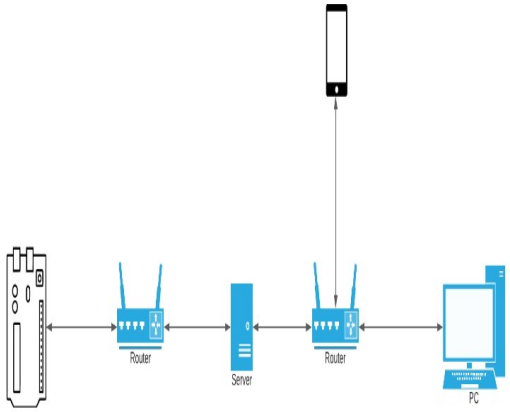

Figure 4. Flowchart by hardware

Figure 4 is a connected system. First, Arduino is connected to the internet (server) via a router, a web that can be accessed via a PC, or a Smartphone that can view data stored on the server via the internet (Website).

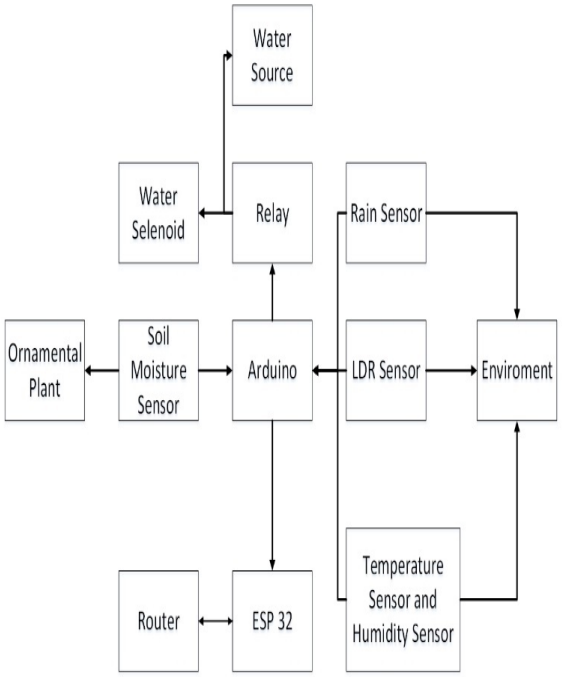

Figure 5. Installing sensors on plants

Figure 5. shows that Arduino is the main center of access to all instruments and Website. The ESP control will connect with the router and then access the GARNUS website system to monitor Ornamental Plant. Then the rain sensor, LDR sensor, and temperature sensor will be in direct contact with the environment to know when to water and fertilize. The next thing directly related to plants is the humidity sensor, which will be integrated with the solenoid for watering the ornamental plants.

This study uses quantitative research methods by making tools they can be operated properly. Using the Waterfall method in the program development stage. After the program is successfully created, the experience questionnaire is filled out [48].

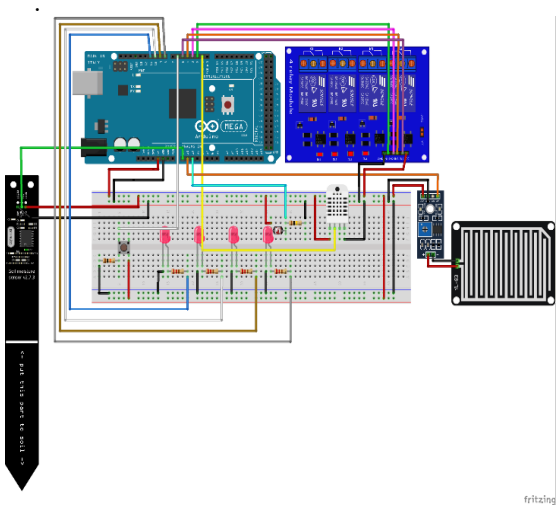

Figure 6.Model Protoype GARNUS

Figure 6 shows the model that will be made by the researcher with the help of a breadboard and LED lights to indicate which mode is used, resistors along with existing sensors and microcontrollers are useful to be shaped in such a way as to help this GARNUS application. It is hoped that the instrument can be used as well as possible. Considering that the pandemic is increasing sharply and the hobby of planting is one of the factors preventing boredom of people at home

In terms of software system development and planning, the author uses the waterfall software development method to build GARNUS monitoring website. The following is a diagram of the waterfall model and its explanation:

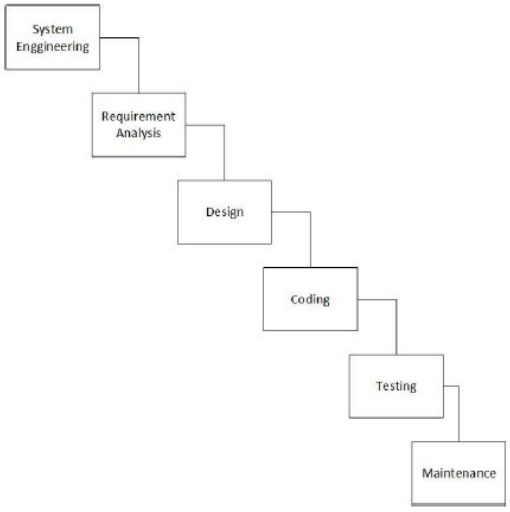

Figure 7. Waterfall

Figure 7 is a description of the method of this Research. Researchers created a UEQ-based questionnaire. Then the researcher conducted a study to see the validity of the questionnaire. The target participants are determined to be residents around the Bandung. Within the stages of information collection, surveys will be conveyed to members to degree the UX of the focused on site. At that point, continue to the information extraction handle, accommodating information looking and information coding negating the study comes about. At that point after that, information investigation was carried out to degree the UX of the GARNUS monitoring website to reach the conclusions of this think about[22]–[24]:

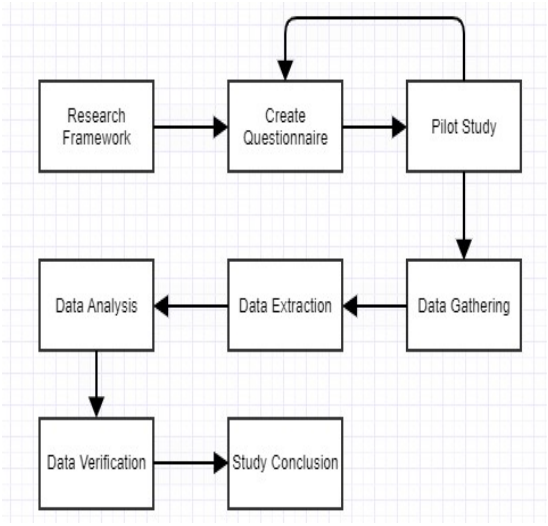

Figure 8. Research Methodology

A. Questionnaire Design

The survey utilized is based on each category of the UEQ system. Designing a Questionnaire and distributing it to the participants using social media-based forms. Questionnaires will be distributed to active users of GARNUS. A user questionnaire involving a pilot consisting of validity and reliability tests was conducted. The number of participants is 70.

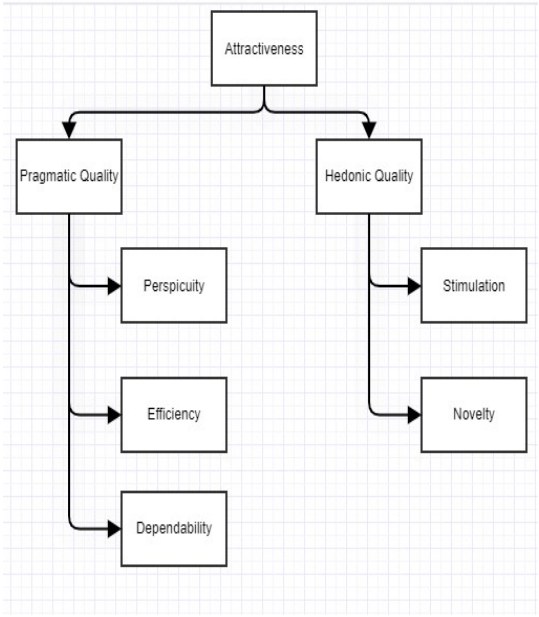

Figure 9. UEQ framework[22]–[24]

B. Data Gathering

The questionnaire results formed in the online form, the User's email used registered on the Website. The result is valid from April 1, 2021 to September 29, 2021. The results of the questionnaire are stored for later processing.

C. Data Set Extraction

This organize comprises recovering information from online gadgets to table preparing programs and performing information determination and information handling. Information handling here is a movement where the information from the shape will be sifted, and it is chosen whether the information is substantial or invalid.

D. Data Analysis

The questionnaire comes about from members who were scaled from -3 to +3. The full answer to the question will be utilized to calculate the normal impact of one task. The average result is calculated based on the average of all questions originating from that attribute. The average result will then be used to calculate the result attribute.

4. RESULT

The following are the results of the experiments used by the Garden Binus System:

Figure 10. Location of IoT Low Cist in Caladium

The instrument is placed on top of the plant, as shown in Figure 10, placed in the taro plant. The nature of the GARNUS instrument is to monitor the natural movement of humidity, rain, pH, etc. After the monitoring is successful, the User can see the progress and results on the Website System.

In previous Research, automation is different from Figure 10. Usually, low-cost IoT is only used for plants for products such as fruits and vegetables, but this Research focuses on someone's new hobby for caring for ornamental plants. The authors consider Research on ornamental plants to be unique when combined with automation and monitoring utilizing the Website

A. Instruments Result

Test results from Research can be seen in this section:

Figure 11. Test and Evaluation GARNUS

Ornamental plants that are connected to the Garnus device. There is a soil moisture sensor in the plant pot that can provide information on soil moisture levels. Then also connected to the hose from the pump to perform automatic watering. In addition, around the pot, a rain sensor can provide data to the Arduino whether it is raining and how much rain intensity is happening. The rain sensor and the pump are assembled into a PCB assembled in a small waterproof control box.

Figure 11 shows if GARNUS low-cost has been successfully set according to the needs where all low-cost instruments can be placed in one container for proper GARNUS maintenance. Another thing is that there are unique things such as water automation settings that are used and successfully implemented. This water automation is used because ornamental plants have special water content and need to be regulated.

Figure 12. Monitoring Result

All wiring is stored and assembled into a control box as above. In the box, there is a red

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power button to turn on and off the whole system. There is a 16x2 LCD to see the status of the system that is running. In this box also installed a DHT sensor and light intensity.

Figure 12 shows if GARNUS with low-cost instruments has successfully carried out monitoring and maintenance, which will be stored on the low-cost GARNUS website in real-time. This monitoring aims to see the results immediately before entering and stored as a database by the Website. Using the Website has meaning if the User wants to conclude the condition of the plant in 1 day. The System results from the Website GARNUS, will be explained in the next section

B. Systems Result

The device that the researcher made is already able to water plants automatically. It can be seen when the soil is dry (tanah kering) >500 and the light is (Cahaya) >1000 lux. As can be seen in the db data below, the device can already water according to the conditions described previously.

Sensor Value

id	sensor_id	value	status	time
14964	14	1,021.0	Tidak Hujan	06/09/2021 15:09
14963	13	1,210.0	Normal	06/09/2021 15:09
14962	12	29.1	Suhu Panas	06/09/2021 15:09
14961	11	65.2	Udara Kering	06/09/2021 15:09
14960	10	383.0	Tanah Lembab	06/09/2021 15:09
14959	14	1,014.0	Tidak Hujan	06/09/2021 15:08
14958	13	1,220.0	Normal	06/09/2021 15:08
14957	12	29.1	Suhu Panas	06/09/2021 15:08
14956	11	64.9	Udara Kering	06/09/2021 15:08
14955	10	389.0	Tanah Lembab	06/09/2021 15:08
14954	14	1,023.0	Tidak Hujan	06/09/2021 15:08

Figure 13. Database Result

According to Figure 13 , this result is a pull from cloud data. Furthermore, the results can be displayed through the Website, as shown in the following image. Figure 13 also shows if the website system has succeeded in displaying the results of sensing several tools that are carried out almost every second. This shows that plants must be treated with special care, such as water because normal ornamental plants must be in the 24-26 range. The air is too dry to be transferred to the plant. The temperature is too hot for watering again. For watering, users don't need to worry because the tool has already carried out automatic watering or can be done manually

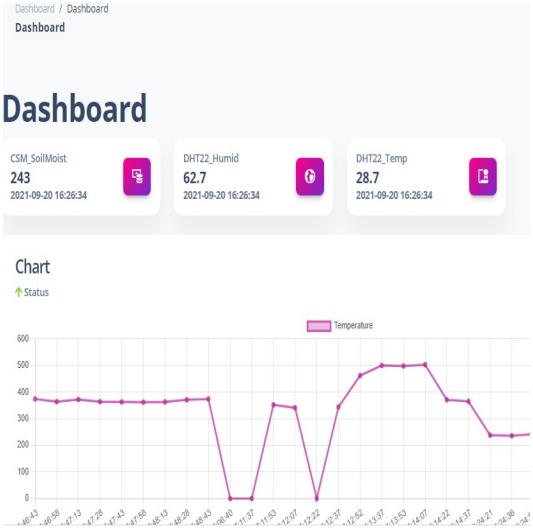

Figure 14. Website Result Main Dashboard

On this page the User can see the latest data from existing sensors such as how much soil moisture, temperature and humidity of the surrounding air, as well as the level of ambient light intensity. Researchers also provide graphs that allow users to see changes in sensor values from time to time within a certain time range.

Figure 14 shows that the Website on GARNUS has succeeded in displaying charts in real-time, this is so that users can conclude the sensor results for several hours or several days. Regular monitoring is needed to see the quality of ornamental plant yields. See the results of the evaluation will be continued in the next session.

C. GARNUS: Instrument Analysis

In this study, a BlackBox test was used to see the results of GARNUS:

Table 3. Blackbox Testing Result

Test Case	Testing Details	Number of tests	Result
Light Intensity Sensor	Identify light	10x	Accepted
Soil Moisture	Identify humidity	10x	Accepted
Rain Sensor	Identify Rain	10x	Accepted
Water pump	Take out water	10x	Accepted

16X2 LCD	Show data	10x	Accepted
Website	Display All result in internet	10x	Accepted

Table 3 shows that all the low-cost instruments used in GARNUS can be used properly, with ten trials. On the other hand, for the final display on the Website, it can also be used properly to display all data. So, it can be concluded if the Garnus instrument can be applied properly generally in the Bandung area, especially in ornamental plants that users commonly use.

Table 3 shows if the test is carried out using a BlackBox. All the components used are acceptable because it uses ten trials, and the results are always successful. The possibility of errors occurring is very slight for users using GARNUS in ornamental plant care

D. Chart Result

The researcher's gadget is Field tests carried out from April 2021 to September 2021 at Bandung, Indonesia. As can be seen in the DB data below, the device can already water according to the conditions described previously.

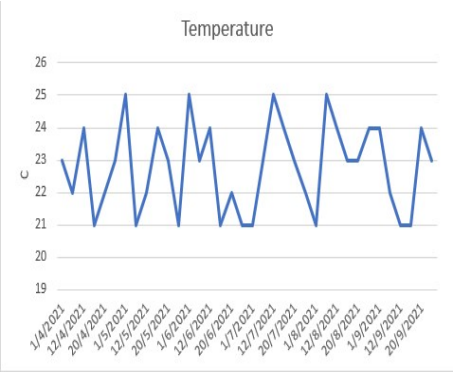

Figure 15. Temperature Result

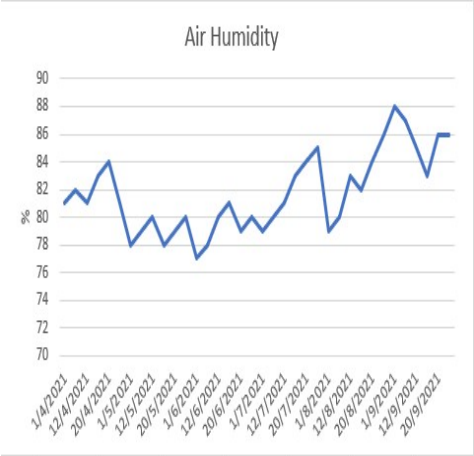

Figure 16. Air Humidity Result

Figures 15 and 16 show the temperature and humidity detection results from the relevant sensors in the period April 2021 to September 2021 in Bandung, Indonesia. Obviously, temperatures range from 21 C to 25 C at the beginning of these months, as the country is experiencing summer. Plants have a minimum and maximum temperature, especially caladium ornamental plants. Thus, examples of automated action sets include the following:

- At the minimum temperature (in the rainy season October - March). it is recommended that ornamental plant cultivation be carried out separately because this period is very high in temperature and water sources.;
- When the maximum temperature conditions (e.g. April-September), the water sprinkler in can increase watering plants because the rain sensor detects no rain;

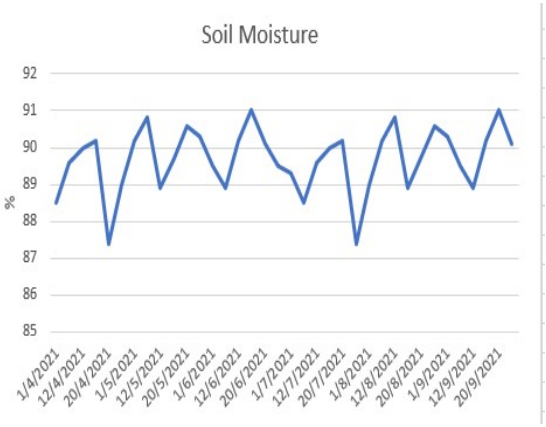

Figure 17. Soil Moisture Result

Monitoring sensor parameters like soil moisture is an important stage of ornamental plant care. Figure 12 shows soil moisture from the relevant sensors in the period April 2021 to September 2021 in Bandung, Indonesia. Soil moisture reflects the water held within the spaces between soil particles, where having this information will offer assistance in understanding soil temperature since summer is such a moo humidity date.

Figure 15-17 shows that GARNUS has succeeded in conducting regular monitoring for several days. This is used to see the impact of ornamental plants because plants can die due to several factors. Users will feel calm if they have a definite reason the plant is growing well or badly. But this Research has weaknesses such as the need for large power for the use of GARNUS required replacement energy or energy management to make GARNUS a Green IoT

E. Website Analysis

On this page, users can see the latest data from existing sensors, such as how much soil moisture, temperature and humidity of the surrounding air, and the level of ambient light intensity. Researchers also provide graphs that allow users to see changes in sensor values over time within a certain time range described in the previous image. Researchers use UEQ (User Experience Question) to test the Website used

There were 70 participants for this study. 80% of the participant are male. Most of the participants were aged between 27 to 55, with 75% of the participant. Regarding employment, household participants are 61%, some are office employees with 23%, 10% are entrepreneurs, 3% are designers, 2% are programmers, and only 1% are managers.

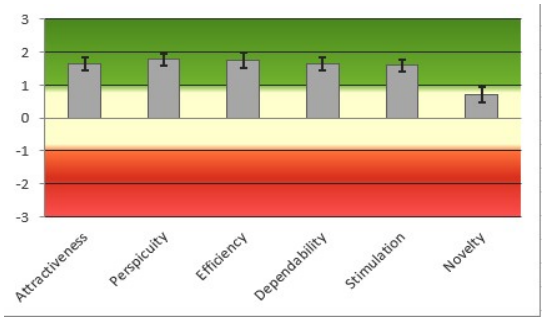

Figure 18. UEQ Result

The attractiveness section scores 1,639, which lies within the positive assessment area, which ranges from 0,8. It means that participants like GARNUS Website System. The perspicuity section got a score of 1,776, receiving a positive result. This means, according to participants, the GARNUS Website System is easy for new people to recognize. The efficiency section got a score of 1.754. This means that participants complete their tasks easily, and it doesn't take much effort. The dependency section scored 1,642. This implies that the site highlights point the page to the proper put, and the site does not divert to another site, making the client feel in control of the interaction. The stimulation category got a score of 1.601, which is located in the positive zone. This implies that clients feel spurred to utilize the site. Lastly, the novelty section got a score of 0.698. This section received the worst results from the others, which means that the GARNUS Website System appearance lacks creativity. This shows the renewability category is challenging to make.

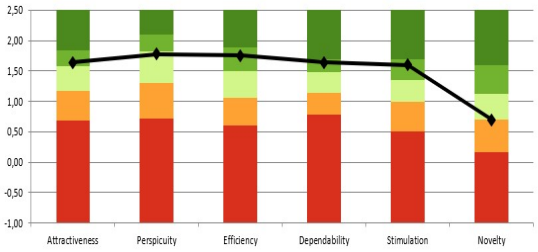

Figure 19. Website UEQ Benchmark Result

Figure 19 shows stores categorized as 'Good' in the Attractiveness, Accuracy, Efficiency, Stimulation, and Dependability categories. This means that the Website is, on an average good website, according to the participants. The Novelty section is categorized as 'Below average', meaning creativity websites need improvement, as innovation is difficult. So the author still needs to do more development on the platform. Especially in terms of novelty

F. Instrument Advantages and Disadvantages

Each IoT machine has its qualities and shortcomings. Within the low-cost instrument GARNUS, the advantages of the instrument can be described below:

- The instrument is very suitable for tropical areas with frequent rainfall

- The instrument not only detects in real-time but also stores data on the Website system
- Not only that, the instrument can also display the results via the LCD

Furthermore, the disadvantages of this GARNUS instrument are:

- The Website System does not have a backup in case information is lost or an error occurs.
- For new places, it is necessary to readjust to the types of plants and their needs.
- GARNUS needs energy management so that its use can be more green IoT but keep low-cost instruments

V. CONCLUSION

Creating an automation tool has several issues, such as the high price of the instrument, the need for an information system website and a website that users widely accept. In this study, a low-cost platform prototype was created, namely GARNUS (Garden Binus), which aims to answer this problem. This prototype is used for the needs of low-cost IoT platform tools, website-based information systems and user-acceptable UX. This prototype is very useful as there is a new sensor for water automation because ornamental plants have special care on water and humidity

Based on the results of the previous explanation, the author has made GARNUS has a function to monitor soil moisture, monitor soil, monitor water availability, install sensors and carry out real-time evaluations through the Website. Sensors work around the plant to provide good accuracy and transmit data to the Website application. In this way, it can automatically assist users in making soil fertilization decisions, providing information about water volume, temperature, soil moisture and real-time information.

After the tool, GARNUS based on a low-cost platform was successfully made. The author conducted several experiments on the low-cost GARNUS instrument and got results.

First, GARNUS has been able to be used both on caladium ornamental plants. and it has been able to monitor on the LCD. GARNUS also has been able to display real-time sensing results on the Website. The rule is that ornamental plants can only be used at pH 7 and Temperatures at 24-26.

Furthermore, the GARNUS experiment successfully passed the evaluation using a BlackBox with 6 experimental components that were tested 10 times, thus getting good reception by users. Furthermore, GARNUS has succeeded in producing a chart for several months of detection. With this, the user can determine the cause of the ornamental plants growing well or not

Finally, GARNUS got a good score on the measurements made by 70 participants where the attractiveness section scored 1,639, the perspicuity section got a score of 1,776, the dependency section scored 1,642, and the novelty section got a score of 0.698, with a threshold of only 0.8 novelty sections. This is a weakness in this study.

Researchers provide suggestions for further Research based on low-cost platform applications such as:

1. Utilization of drone technology for monitoring
2. Utilization of Lora-based communication (long distance)
3. Utilization of energy management to create green IoT

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