Development of mobile-based apps towards smart farming technology in Agro Innovation Park (Tagrinov) Management

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Abstract. As an effort to optimize the use of smart farming technology aimed at increasing efficiency in agriculture, a study was carried out at Agro-Innovation Park (Tagrinov), a place for education and learning of innovative home yard utilization concept. The smart farming applied in Tagrinov were irrigation control systems, pH and nutrition control systems of hydroponic plant, and temperature and humidity control in aeroponic systems. Those three monitoring and controlling systems were integrated in the mobile apps called Tagrinov 4.0. The deployment of control mechanism involved some systems, namely communication testing of android application using firebase server for irrigation; the Arduino Mega 2560 for pH level and nutrition control of hydroponic plant, and the Arduino Uno, DHT22 and DS18B20 sensors for temperature and humidity control of the aeroponic system. The test results showed some advantages of smart farming application in Tagrinov. Irrigation control system using internet network can be easily carried out by users. Arduino makes the system automatic, the pH sensor works as pH meter, the nutrients turn on and off when the pH value and nutrients are appropriate. The aeroponic sensor system read the temperature and humidity in the parent seed nursery, to activate the sprayer and makes the water become mist. All smart farming technologies were operated through mobile apps making these systems more efficient.

1. Introduction
Millennials are a demographic group who were born in the period of the 1980s to the 2000s. They are agricultural actors being actively involved in realizing modern agriculture with new models and innovations such as precision agriculture, vertical farming and smart agriculture [1] as part of the penetration in the process of transforming local wisdom into digital agriculture [2]. The categories of this generation are currently 17-39 years old [3] while the Indonesian Ministry of Agriculture defines the millennials as those aged 19-39 years at this time [4]. It is estimated that the number of millennials until 2020 is 69,900,740 people or 25.87% of the total population of Indonesia [5]. The millennial is the engine of modern agricultural development.

Smart Farming is a digital farming development effort to produce superior, precise, efficient and sustainable products. The success of this activity requires the support of conducive conditions in the transitional era. One of the supportive conditions is the learning process of digital agriculture for agricultural actors.

Agro Innovation Park (Taman Agro Inovasi/Tagrinov), located in Bogor, Indonesia, is a showcase of technological innovations from the Indonesian Agency for Agricultural Research and Development of the Ministry of Agriculture, as a place for education and learning about the concept of innovative garden utilization. In the last three years (2018-2020), Tagrinov has been visited by 6,186 visitors [6].
As much as 3,280 persons or 53.02% from the total visitors are millennial generations, consisted of: 70 persons or 1.13% attended training course activities, 3,089 visitors or 49.94% participated in edutourism activities, and 171 persons or 1.96% participated in internship and research activities. This condition illustrates that Tagrinov's role in introducing Smart Farming to Generation Y is very strategic. This is certainly become a challenge to sustain the effort in increasing the interest of visitors, especially Y generations to be interested in modern agriculture. When introducing mobile-based tools, focus should be given to younger, more educated farmers growing more specialized crops [11].

In the frame of dealing with this challenge, Tagrinov contrives technology and garden display that accommodate the development of digital agriculture. One of technologies is improving the performance of Smart Farming based on Mobile Apps. This mobile apps, named Tagrinov 4.0, comprised irrigation control systems, pH and nutrition of hydroponic; as well as temperature and humidity control in aeroponics systems. Therefore, the objectives of this research are to determine the effectiveness of mobile apps development providing ability in irrigation control, pH and nutrition of hydroponics, as well as temperature and humidity control in aeroponic systems as a part of smart farming implementation in Tagrinov management.

2. Methodology
The study was conducted at Agro-Innovation Park (Tagrinov), a place for education and learning of innovative home yard utilization concept of Indonesian Center for Agricultural Technology Assessment and Development (ICATAD) since February until March 2020. Tagrinov display arrangement featured: garden displays and technology displays. The garden display is in the form of land arrangement by taking into account the 5 functions of the yard, namely: living shop, living pharmacy, living barn, living bank, and aesthetics / beauty. While technology display includes following activities: planting media, cropping cycle, cultivation methods, pest management, irrigation systems, fertilization, and nurseries [7].

![Figure 1. Tagrinov display.](image)

In this light, this paper presents the implementation of smart farming through the use of Tagrinov 4.0 apps in the irrigation control, hydroponic, and aeroponic management systems. The parameters of this study were, among others, the effectiveness of solar panel utilization as energy sources connected to raspberry, solenoid valve and sprinkle in the irrigation system; the effectiveness of micro controller pH and nutrient, water pump, TDS dan pH sensor in the hydroponic management system; as well as the effectiveness of temperature and humidity reader, dan sprayer in aeroponic management system.

This study carried out the following activities (a) identifying problem and needs; (b) designing flowcharts, circuit schemes, and user interface (UI) prototype; (c) assembling components and developing android application program; and (d) testing the function of android application program.
Irrigation control utilizes existing energy sources (solar panels) as a source of electricity to control the micro-processor (raspberry pi 3) as a means of controlling water distribution to each irrigation sector in Tagrinov. Internet network is used as a liaison between the irrigation controller and the Firebase database which is directly connected to the Tagrinov 4.0 android application [8].

Control of pH and nutritional value utilizes a PLN electricity source that drives the Arduino Mega 2568 micro controller to control the minimum and maximum limits of nutritional and pH value in the needs of a plant [9].

The temperature and humidity regulation in aeroponic planting systems utilizes the DHT22 sensor as a temperature and humidity reader for the green house, the DS18820 sensor as a temperature and humidity reader in aeroponic systems and a sprayer as a temperature and humidity stabilizer in aeroponic systems [10].

3. Results and Discussion

3.1. Irrigation system control
The Tagrinov irrigation system controls (turns on and off) the irrigation pump engine. The mechanism is by utilizing solar electrical energy stored in a battery that has been converted to 220 volts AC, then
connected via a raspberry power cable to the microprocessor irrigation control. Irrigation control connected to the internet and Firestore database is controlled via the Android application.

![Figure 5. Circuit scheme.](image)

The Android application activates the solenoid valve to control water distribution according to the arranged irrigation channels to each (four) garden sectors. Technically, if Android application sends data value 1 (true = on) in sector 1, then the data is saved to Firebase to be checked whether the distribution in the destination sector is working or not. Having connected a power source to the microcontroller enable the irrigation system to be controlled remotely via an Android application connected to the internet network. Another important characteristic of IoT services can be the deployment of a large number of the same type of devices and applications. Each device and application perform the same activity and transports information to a service centre at the same time [12].

3.2. pH and nutrition control of hydroponic

The Android application system functions to set the value range of adequate pH and nutrient of a certain plant. The range values are sent to the database and then read by the hydroponic controller as a means of monitoring the adequacy of nutrients and pH of a plant.

The pH sensor reads the pH value, while the TDS sensor reads the PPM value of a plant. These two data are then compared with the predetermined value range of adequate pH and nutrient values. The data recorded by the sensor is then sent to the database as monitoring data in the Android application in real time.

As the response from the pH sensor, if the pH value is above the predetermined range, the pump in the pH down tube will flow the pH down liquid to the core tube to stabilize the pH value. Meanwhile, if the pH value is below the predetermined range, the pump on the pH up tube will flow pH up liquid to the core tube to stabilize the pH value. If the pH value is already within the predetermined value range, the pump itself will stop working.

As the response from the TDS sensor, if the PPM value is outside the predetermined range, the pump on the nutrient A and B will work to flow each nutrient into the core tube until the PPM value in the core tube is in accordance with the predetermined range. The pump that delivers nutrients will stop by itself.

3.3. Temperature and humidity settings in aeroponic systems

In the aeroponic system, the DS18B20 sensor is used to read the temperature, while the DHT22 sensor reads the temperature and humidity in the nursery garden. When the temperature in the aeroponic media is outside the predetermined value range, the pump will automatically turn on to create fogging on the aeroponic media and function to reduce and stabilize the temperature in the aeroponic media, where the misting process is carried out by a sprayer under the aeroponic plant.
Figure 6. Irrigation system flowchart.

Table 1. pH value testing results.

| Testing | Time   | pH Sensor | pH Meter | Difference | pH up pump | pH down pump |
|---------|--------|-----------|----------|------------|------------|--------------|
| 1       | 18:57  | 5.4       | 5.4      | 0          | on         | off          |
| 2       | 19:07  | 6.3       | 6.3      | 0          | off        | off          |
| 3       | 19:17  | 6.3       | 6.3      | 0          | off        | off          |
| 4       | 19:27  | 6.4       | 6.4      | 0          | off        | off          |
| 5       | 19:37  | 7.9       | 7.7      | 0.2        | off        | on           |
| 6       | 19:47  | 7.3       | 7.2      | 0.1        | off        | on           |
| 7       | 19:57  | 6.9       | 6.9      | 0          | off        | off          |
| 8       | 20:07  | 6.9       | 6.9      | 0          | off        | off          |
| 9       | 20:17  | 6.8       | 6.8      | 0          | off        | off          |
| 10      | 20:27  | 6.6       | 6.5      | 0.1        | off        | off          |
| Average |        | 6.68      | 6.64     | 0.04       |            |              |

When the temperature in the aeroponic system is within the predetermined value range, the pump will turn off and stop fogging activities. When the sensor reads the temperature and humidity on aeroponic media, the data is sent by the micro controller to the firebase database in real time. The data is retrieved and displayed on the android application.

Those three smart farming technology displays are integrated in one android application called Tagrinov 4.0. Through this application, irrigation control, pH and nutrition control of hydroponic plant, as well as temperature and humidity control in aeroponic systems can be monitored and controlled in real time. To develop an integrated application, android platform for smartphones is the best to be utilized. This decision is based on the rationale that the Android OS has greater freedom in its development program [12].
Table 2. Nutritional value testing results.

| Testing | Time   | TDS sensor (ppm) | TDS meter (ppm) | Difference | A and B pump |
|---------|--------|------------------|-----------------|------------|--------------|
| 1       | 20:32  | 520              | 550             | 30         | on           |
| 2       | 20:42  | 655              | 653             | 2          | off          |
| 3       | 20:52  | 658              | 659             | 1          | off          |
| 4       | 21:02  | 655              | 661             | 6          | off          |
| 5       | 21:12  | 655              | 661             | 6          | off          |
| 6       | 21:22  | 652              | 661             | 9          | off          |
| 7       | 21:32  | 652              | 661             | 9          | off          |
| 8       | 21:42  | 650              | 661             | 11         | off          |
| 9       | 21:52  | 650              | 659             | 9          | off          |
| 10      | 22:02  | 647              | 656             | 9          | off          |
| Average |        | 639.4            | 648.2           | 9.2        |              |

Table 3. DHT22 censor testing results.

| Time   | Temperature | Humidity | A and B pump |
|--------|-------------|----------|--------------|
| 10:30  | 29.00 °C    | 73 %     | off          |
| 11:00  | 29.80 °C    | 71 %     | off          |
| 11:30  | 30.50 °C    | 68 %     | on           |
| 12:00  | 29.20 °C    | 73 %     | off          |
| 12:30  | 30.60 °C    | 68 %     | on           |

Table 4. DS18B20 censor testing results (aeroponic system).

| Time   | Temperature | A and B pump |
|--------|-------------|--------------|
| 10:30  | 28.00 °C    | off          |
| 11:00  | 29.00 °C    | off          |
| 11:30  | 30.50 °C    | on           |
| 12:00  | 29.50 °C    | off          |
| 12:30  | 29.00 °C    | off          |

Figure 7. Tagrinov 4.0 smart farming features.
4. Conclusion
Tagrinov 4.0, an integrated android application, showed some advantages of smart farming implementation in Tagrinov. The irrigation control system which functions to distribute water to the four sectors in the land works well. The pH and nutritional value control on the hydroponic system and the temperature and humidity control in the nursery on the aeroponic system also work efficiently. Through this application, irrigation system, pH and nutrition control of hydroponic plant, as well as temperature and humidity control in aeroponic systems can be monitored and controlled in real time.

As a place for education and learning about innovative technology for home yard utilization, Tagrinov has a strategic role in literating and persuading the millennials as actors of modern agricultural development to be more interested in playing an active role in modern agricultural development.

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