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GP Nangka SMART Fertigation System: Innovation Research for Sarawak Agriculture

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Abstract

This paper is presenting a design of a smart agro system named GP Nangka SMART Fertigation System. As Internet of Things (IoT) nowadays becoming a trend in the technology's world, it has been implemented in designing and developing this system. There are three (3) main components in this system which is hardware unit, server and mobile application. In hardware unit, it consists of three main modules which includes an IoT module, actuator module and sensor module. The main module in hardware unit, which is an IoT module, are acting as a communicator and a brain of this system. The second module is an actuator module which is acting as a controller for the pump and the third module is a sensor module which will collect data from sensors attached to the system. The second component in this system, which is server units mainly to handle or act as an intermediary between hardware and mobile application in communication process. The third and the last component in this system is a mobile application designed to collect and display a real-time to enable the users to monitor and control the system from anywhere as long as their mobile devices are connected to the Internet. This system was tested and worked effectively on a chilli fertigation farm in Sibu, Sarawak. The results showing that the system was useful for Agricultural 4.0, in which technology can help farmers to increase their productivity while significantly decreasing costs with friendly used concepts.

Keywords: - smart farm, Internet of Things (IoT), sensor, water control, EC meter measurement, Sarawak

1. Introduction

Agriculture in Malaysia today is showing rapid progress in the current of globalization and modern technology with the existence of commercial agriculture in various agricultural crops which provides lucrative results to farmers in Malaysia. As a result, various types of crops are cultivated to provide profitable returns to farmers such as commercial oil palm farming, rubber plantations, chili fertigation, coconut plantations etc.

Although the agricultural sector faces several issues and challenges, it is important as a supplier and guarantor of food security, employment opportunities, export earnings and a generator of the national economy. This sector will also always be relevant as a source of raw materials for the development of agro-based industries. Human resource development will continue to be a priority to ensure a dynamic and internationally competitive workforce. The development of a knowledge-based economy and innovation accompanied by the emergence of new technologies and globalization will influence the growth trend of demand for skills and expertise in the future as well as create new economic opportunities that can lead to increased incomes of Malaysians.

The field of agriculture is moving in line with the development of science and technology to produce better quality crops. Smart Agricultural Innovation refers to the use and integration of the latest technologies more widely in the field of agriculture, aimed at increasing the quantity and quality of harvested produce. The idea is not only to give farmers the opportunity to increase their income but also to analyze agriculture and monitor crop yields quickly without a large workforce.

1.1 Problem Statement

Over the past few years, Internet of Things (IoT) has become one of the most important technologies of the 21st century. Now that all of us can connect everyday objects—kitchen appliances, cars, thermostats, baby monitors—to the internet via embedded devices, seamless communication is possible between people, processes, and things. In this hyperconnected world, digital systems can record, monitor, and adjust each interaction between connected things. The physical world meets the digital world—and they cooperate.

IoT solutions are focused on helping farmers close the supply demand gap, by ensuring high yields, profitability, and protection of the environment. The approach of using IoT technology to ensure optimum application of resources to achieve high crop yields and reduce operational costs is called precision agriculture. IoT in agriculture technologies comprise specialized equipment, wireless connectivity, software and IT services.

There are many problems of conventional agriculture consist inconsistence of crop watering works lead to over/less watering and infertile crop. Other than that, a fertilizing process are carried out manually, causing the crop to receive imbalance or insufficient nutrients. In addition, conventional agriculture used of a complex, not user friendly and expensive farming system.

1.2 Aims and Objectives

This innovation of Smart fertigation system is developed with the following objectives:

i. Digitalize agricultural processes.

ii. Introducing new technology in Agriculture to small farmers.

iii. Creating an affordable and friendly user system for small farmers.

1.3 Scope of Study

The approach of using GP Nangka SMART Fertigation System system to ensure optimal use of resources to achieve high crop yields and reduce operating costs. By applying the user-friendly concept to this system, this study is focusing on “smallholders”. This system has been tested at Pusat Latihan Pertanian Moden DUN Nangka and has been expanded to use in chilli farms in Jalan Dato Baru and Jalan Alu-alu in Nangka, Sibu. This system has also been installed at Pejabat Pertanian Nanga Machan, Kanowit and got compliment from Deputy Chief Minister of Sarawak, YB Datuk Amar Douglas Unggah Embas. It takes 6 months for the duration of designing and developing the system. It starts with developing the system design and finished with documentation process. To ensure the satisfactory and the reliability of the system, a few tests need to be carried out before this system could be implemented. This system has three (3) main components which is a hardware unit, server, and mobile application.

2. Literature Review

2.1 Fertigation

Fertigation is an agricultural technique that maximizes crop yield through controlled application of water and fertilizers. This application also ensures that negative effects of fertilizer leaching to the roots, soil and groundwater are avoided. When applied in a soilless system, where substrates and media such as rockwool, perlite, vermiculite or peat are used, cultivation of food crops can be done on infertile lands or urban areas. Elimination of soil also improves yield through prevention of soil-borne diseases and increases multiple growing cycles without the need to replenish nutrients and soil conditioning. Furthermore, fertigation under a rain-shelter system allows cultivation of crops in areas where excessive rain, sunshine or wind inhibits conventional cultivation of the required food crops.

“Smallholders” encompassing small farmers who own or cultivate the land they farm. They are usually considered as a part of the informal economy (due to not registering, tending to be excluded from the aspects of labor legislation, lacking social protection and having limited records).

In Malaysia, fertigation of vegetables such as chillies, cucumbers and tomatoes, as well as high-valued fruits such as rock melons are widely practiced. Crop yields of up to five times per unit area have been achieved and this has contributed to its increasing public interest and appeal. MARDI plays an important role in generating innovative techniques that are tailored to suit requirements of local food crops, as well as utilizing the advantages of fertigation system to expand into cultivating non-local food crops that would otherwise be difficult to grow through conventional methods (Bujang, 2017).

2.2 Internet of Thing (IoT)

IoT describes the network of physical objects “things” that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. These devices range from ordinary household objects to sophisticated industrial tools. With more than 7 billion connected IoT devices today, experts are expecting this number to grow to 10 billion by 2020 and 22 billion by 2025 (Gurbani, 2021).

Business Intelligence survey expects that the adoption of IoT devices in the agriculture industry will reach 75 million in 2020, growing 20% annually. At the same time, the global smart agriculture market size is expected to triple by 2025, reaching $15.3 billion as compared to being slightly over $5 billion back in 2016 (Muangprathub, 2019).

Advanced technologies can bring benefits to the majority of people. In the recent years, the IoTs has begun to play a major role in daily lives extending the perceptions and ability to modify the environment. Particularly the agro-industrial and environmental fields apply IoTs in both diagnostics and control. In addition, it can provide information to the final user/consumer about the origin and properties of the product (Talavera et al., 2017). Thus, this paper aims to apply IoTs for computer aided optimization of agriculture.

While the idea of IoT has been in existence for a long time, a collection of recent advances in a number of different technologies has made it practical.

i. Access to low-cost, low-power sensor technology. Affordable and reliable sensors are making IoT technology possible for more manufacturers.
ii. Connectivity. A host of network protocols for the internet has made it easy to connect sensors to the cloud and to other "things" for efficient data transfer.
ii. Cloud computing platforms. The increase in the availability of cloud platforms enables both businesses and consumers to access the infrastructure they need to scale up without actually having to manage it all.
iii. Machine learning and analytics. With advances in machine learning and analytics, along with access to varied and vast amounts of data stored in the cloud, businesses can gather insights faster and more easily. The emergence of these allied technologies continues to push the boundaries of IoT and the data produced by IoT also feeds these technologies.
iv. Conversational artificial intelligence (AI). Advances in neural networks have brought natural-language processing (NLP) to IoT devices (such as digital personal assistants Alexa, Cortana, and Siri) and made them appealing, affordable, and viable for home use (Oracle, n.d).

IoT solutions are focused on helping farmers close supply-demand gaps, by ensuring high yields, profitability, and environmental protection. IoT in agricultural technology includes specialized equipment, wireless connectivity, software and IT services.

Technology can be used to produce a variety of innovations and facilitate human daily work as well as help solve related problems. It is the same in agriculture that technology helps in the process of transformation to increase production, thus ensuring the security of food resources.

2.3 Mobile Application

A mobile application, most commonly referred to as an app, is a type of application software designed to run on a mobile device, such as a smartphone or tablet computer. Mobile applications frequently serve to provide users with similar services to those accessed on PCs. Apps are generally small, individual software units with limited function. This use of app software was originally popularized by Apple Inc. and its App Store, which offers thousands of applications for the iPhone, iPad and iPod Touch (Islam et al., 2010).

A mobile application also may be known as an app, web app, online app, iPhone app or smartphone app. Mobile applications are a move away from the integrated software systems generally found on PCs. Instead, each app provides limited and isolated functionality such as a game, calculator or mobile web browsing. Although applications may have avoided multitasking because of the limited hardware resources of the early mobile devices, their specificity is now part of their desirability because they allow consumers to hand-pick what their devices are able to do (Techopedia, 2019).

3. Methodology

This chapter will be described on the Development Stages in developing *GP Nangka SMART Fertigation System* from early stages which is selecting the framework until the last stage which is applying the system by the user.

3.1 General Framework of the GP Nangka SMART Fertigation System Development

In the General Framework of *GP Nangka SMART Fertigation System*, there are six (6) stages as illustrated in Figure 1. It starts with developing the system design and finished with documentation process. To ensure the satisfactory and the reliability of the system, a few tests need to be carried out before this system could be implemented.

This system consists of three (3) main component which is an IoT Control Box, Mobile Apps and the server. In this system, the IoT Box Unit was designed to be a weatherproof unit and based on the process happen in the conventional fertigation system. As a main unit for this system on site, this box consists of an electronic part and handles the communication between sensors, actuators and the server. This unit is connected to the Electrical Conductivity (EC) sensor to measure the concentration of the total soluble salts in a fertilizer in the mixture storage tank. It is also connected to a water level sensor which will measure the contain of the mixture storage tank since in some condition, this system will operate automatically to drip and refill the mixture storage tank (if set by user).

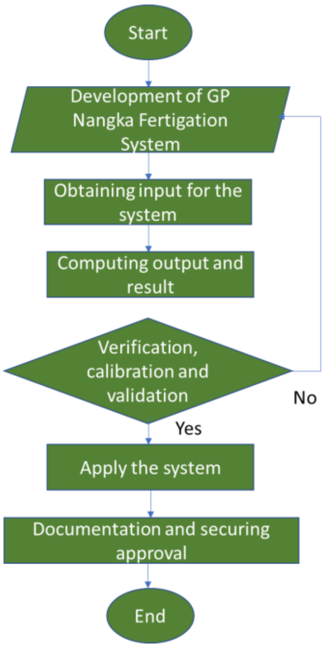

Figure 1: Framework of the *GP Nangka SMART Fertigation System* development

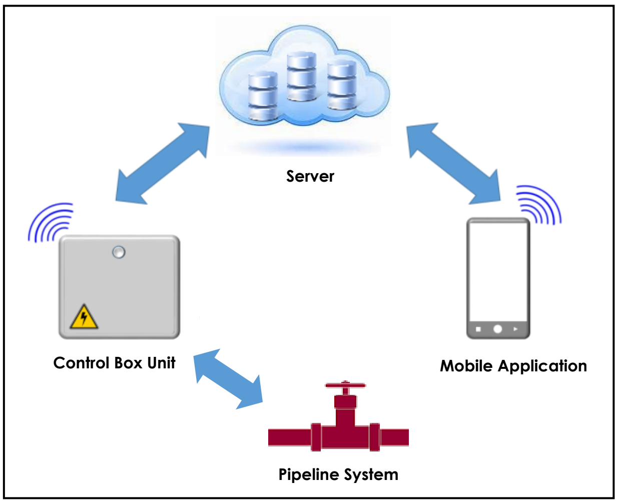

Figure 2: System design and overview

To control this system, a mobile application was designed and developed based on conventional farmers view and perspective. The interface was designed as simple as possible to make sure this application is easy to be adopted by normal farmers without a need of special knowledge and skills in technologies. The data displayed on the application are the same as what was displayed in the conventional tools that the farmer use to measure the thickness of the fertilizer and the difference between this tool is that the farmers do not need to be on site to monitor this parameter. To communicate with the IoT Control Box Unit, this application is connected to the same server where the IoT Control Box Unit was connected. Figure 3 show the interface of this application. With this mobile application, user will be able to control the watering system from anyway as long as their smart phone and control box are connected to the internet. Besides, with this mobile application, user also be able to enable the automatic watering system by assigning the time and the day of watering.

To integrate the IoT Control Box Unit and the mobile application, a server which is hosted in cloud are used. This is to reduce cost for implementation of this system and the maintenance of the system. Most of the complex system currently available in the market come with their own server which will cost the user a lot not only during the implementation but also it will cost a lot to the user for the maintenance and the user need to have a knowledge and skills related to server maintenance. This might burden the user especially the small farmers. By using the server that are hosted on cloud, the user the maintenance cost will be reduced more than 60% and the implementation cost also could be reduced because the user does not need to purchase the physical server. This server mainly designs to become intermediary between the IoT Control Box and mobile application.

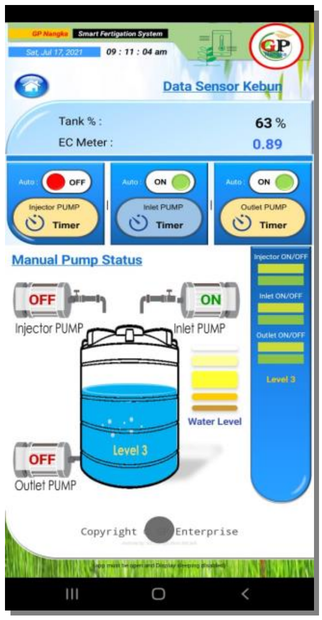

Figure 3: Mobile application interface

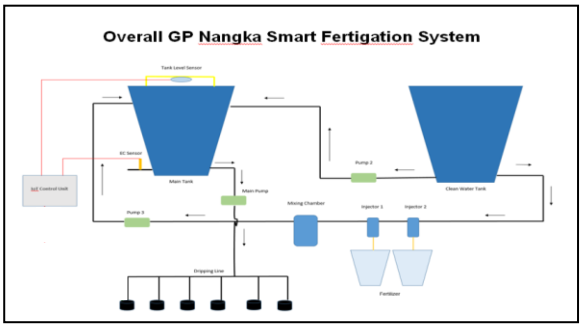

Figure 4: Diagram *GP Nangka SMART Fertigation System* (IoT System)

Verification is a procedure to establish the accuracy of the system by examining and testing the system whether it can perform and behave accordance to the real environment. This process was involved the examining and the translation of the system design conceptual.

In this stage, there are few processes involved including calibrating the EC sensor to ensure the EC reading are accurate and aligned with the tools used in conventional fertigation system.

Besides validating data from the sensor, the consistency check for the system also has been done in this phase. This process is important to make sure the system reacts accordingly to the instruction given by the user and accordingly to the sensors.

Finally, documenting the important details and applying the copywrite for this system are last step before it could be published and deploy to user sites. The documentation is done to make sure there is a reference in future to maintain or to improve the system.

4. Finding and Analysis

This fertigation system was developed based on the view and perspective farmers which is currently using conventional fertigation system and focusing on small farmers in terms of start-up cost, maintenance cost and user friendliness.

Table 1: Authenticity/Novelty

Conventional	Smart Fertigation
Manual & Old System	Digitalize & Computerize System
Old method with rough works	New technic & method for farmers
Less and low-quality crops yield	Increase & high-quality Crops yields

4.1 Digitalize Agricultural Processes

With this system, small farmers can monitor and control farming processes wherever they are provided they have an internet connection at the agricultural site and the location of the user/farmer. Among the functions offered in this system are the reading EC value to measure the thickness or contain of fertilizer, water level in the main tank or mixture tank, Pump control either manually or automatically (using the timer available on the system).

Among other purposes of the development of this system is to respond to the challenges of the Sarawak state government in introducing modern agriculture and provide opportunities and exposure to small farmers in the field of technology, especially related to agriculture.

4.2 Introducing New Technology in Agriculture to Small Farmers

The application of technology in agriculture is now one of the trends in the field of agriculture in the country or around the world. However, most of the technologies applied to agriculture at present are costly which are mostly focused on agricultural entrepreneurs who have large capital and market. In line with the hopes and cries of the government, we have produced technology that can be applied in the agricultural management process, especially to small farms.

This GP Nangka Smart Fertigation System has been successfully copyright registered with MyIPO on 4/12/2020 (LY2020006464). Through collaboration with GP enterprise, this system has been successfully installed in 2 chilli farms in Nangka, Sibu. As a result of success in Nangka, Jabatan Pertanian Sarawak has interest and requested to install another set in Machan, Kanowit.

With the application of Internet of Things (IoT) in fertigation system, that are introduced, it is able to give a good impact especially in reducing management costs, saving time and guaranteeing good results. Apart from that, the cost of this system starter kit is also affordable. IoT can make agricultural industry processes more efficient by reducing human intervention through automation especially during the pandemic period.

4.3 Creating an Affordable and Friendly User System For Small Farmers

This system has been deployed at Pusat Latihan Pertanian Moden DUN Nangka and has been expanded to use in chilli farms in Jalan Dato Baru and Jalan Alu-alu in Nangka, Sibu.

Due to the satisfactions of the user from previous two (2) location and in collaboration with Jabatan Pertanian Sarawak, this system has also been installed at Pejabat Pertanian Nanga Machan, Kanowit and got compliment from Deputy Chief Minister of Sarawak, YB Datuk Amar Douglas Unggah Embas.

IoT technologies has a potential to transform an agriculture fields in many aspects and this system are one of the examples using this technology. Data collected by the system sensors, process, respond and react with the input of data through the internet. This enable user easily to monitor and control their farms.

4.4 Impact

The use of this system has a significant impact as follows:

i. Reduce the cost of water and fertilizer on crop areas
ii. Increase the fertility of crop by increasing the consistency of watering and fertilizing process
iii. Increase the amount and quality of crop's yields
iv. Improve the skills in using apps and smart fertigation system among farmers

5. Conclusion

Internet of things is a new technology which provides many applications to connect the things to things and human to things through the internet. Each object in the world can be identified, connected to each other through internet taking decisions independently. By applying the user-friendly concept to GP Nangka Smart fertigation system, this innovation research is focusing on "smallholders" for Sarawak Agriculture. With the reasonable price of this system, the farmers can reduce the labour cost because with this system they are able to monitor their watering and the fertilizing process at their farm. Indirectly they could reduce the working hour on site.

The role of the researcher is to support the agricultural techno development system, create awareness and enhance the competencies of other individuals in terms of care and production of products. The IoT concept applied in this system is to improve quality and reduce costs.

GP Nangka Smart fertigation system solutions are developed to monitor crop fields with the help of sensors and automate irrigation systems. Farmers can monitor the condition of the farm from anywhere. They can also choose between manual and automatic options to take the necessary actions based on this data. Smart farming is very effective when compared to conventional approaches.

Smart farming based on IoT technology that apply in this system enables growers and farmers to increase productivity ranging from the quantity of fertilizer used and enables efficient use of resources such as water.

Apparently, technology and innovation, the result of the creativity of researchers, are able to be an important factor in driving the transformation of agriculture in the country and open up opportunities for the community to venture into this field. The motivation for this innovation is to bring in a better understanding of IoT and help the research community to bring in more advancements and contributions to the area of IoT.

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