Developing An Android-based Smart Hydroponic Farming (SHIFA) Monitoring System

Marti Widya Sari[1,*], R. Hafid Hardyanto[2], Prahenusa Wahyu Ciptadi[3], Firdiyan Syah[4], Ginanjar Setyo Nugroho[5]

[1,2,3,4] *Department of Informatics, Faculty of Science and Technology, Universitas PGRI Yogyakarta, Indonesia*
[5] *Department of Digital Business, Faculty of Business, Universitas PGRI Yogyakarta, Indonesia*
[*]*Corresponding author. Email: marti@upy.ac.id*

ABSTRACT
This research aims to develop agricultural digitalization through the Smart Hydroponic Farming Model, using IoT technology, in greenhouses to assist in monitoring plants, so that plant growth and yields are optimal. The research method used is the research and development method, with research stages including: literature study, survey and observation, SHIFA system model design, coordination with research partner, hardware and software system requirements analysis, system prototype creation and system testing. Development of the SHIFA system model, using solar cells as energy that will be used in the greenhouse as a test field. The way the system works is starting from the solar cell panel which is connected to the Arduino microcontroller, then reading the sensors, including temperature sensors, humidity sensors, pH sensors and controlling the power source from the solar cells. In this research, we have succeeded in creating an IoT-based smart hydroponic farming and Android-based monitoring system, which can be monitored online and in real-time from anywhere. The benefit of the proposed innovation for partners is that they could recognize and develop modern agricultural systems, which will have an impact on the increasing number of millennial farmers who understand the digitalization of agricultural systems.

Keywords: *Smart Farming, Hydroponic Farming, Monitoring System, Internet of Things, Android.*

1. INTRODUCTION

Climate change has had a significant impact on agriculture [1] and is expected to continue to affect food production directly and indirectly [2]. Increasing average temperatures, changing rainfall patterns, increasing changes in temperature and rainfall patterns, changes in water availability, frequency and intensity of extreme events, sea level rise and salinization, disruption in ecosystems, will all have major impacts on agriculture, forestry and fisheries [3], [4]. The extent of these impacts depends not only on the intensity and period of change, but also on the combination of both, more uncertain, and local conditions [5], [6]. This condition will increasingly affect food sources, so ways are needed to increase food security [7], [8].

To achieve food security and agricultural development goals, adaptation to climate change and lower emission intensity are necessary [9]. These changes can also affect food prices globally [10]. Increasing food security while contributing to reducing climate change and conserving natural resources [11]. More productive and resilient agriculture requires major changes in the way land, water, soil nutrients and genetic resources are managed to ensure that these resources are used more efficiently [12].

The agricultural sector is a sector that plays a contributing role in GRDP (Gross Regional Domestic Product) based on the amount of production, level of productivity and total value of agricultural production. An important subsector in the economy and important in maintaining the availability of primary food needs in Bantul Regency, namely the food crops subsector. In general, the commodities contained in the food crop subsector are rice, corn, cassava, sweet potato, peanuts and soybeans. This food crop is very vulnerable to extreme and uncertain climate changes, such as those currently starting to occur, which will result in a decline in agricultural production. Therefore, a way is needed so that the production of these food crops is not affected by extreme climate changes. One method that has been

A. Kusuma Wardana (ed.), *Proceedings of the 2023 International Conference on Information Technology and Engineering (ICITE 2023)*, Advances in Intelligent Systems Research 179,
https://doi.org/10.2991/978-94-6463-338-2_23

proposed by several researchers is the development of a Climate-Smart Agriculture (CSA) system.

The impacts of climate change will have a major impact on agricultural production, with production decreasing in certain regions and increasing production variability. Local impacts will bring global imbalance [13]. In general, climate change can cause an increase in crop productivity and livestock productivity in mid to high latitudes, and a decrease in tropical and subtropical areas [14]. Among the most affected areas are economically vulnerable countries that are already food insecure and several important food exporting countries. This will cause significant changes in trade, impacting prices and the situation of net food importing countries. As a result, climate change is expected to increase the gap between developed and developing countries due to more severe impacts on already vulnerable developing countries, exacerbated by relatively lower technical and economic capacity to respond to new threats.

In recent years, there has been a lot of use of internet of things (IoT) technology to solve problems in the agricultural sector, especially those related to climate change, as well as decision support systems for more accurate determination of agricultural processes [15]. After processing the data obtained from the sensors, the system will provide estimates to farmers, so that farmers can make smarter decisions for agricultural processes [16]. Research conducted by Moon, et al. [17], researched that the volume of data collected by various IoT sensors used in smart agricultural applications is increasing, requiring large data storage and processing. for agricultural applications is a big challenge. Specifically, this study applies three transformation-based lossy compression mechanisms to five weather data sets collected from different sampling granularity of IoT weather stations. The results show that there is a strong positive correlation between the concentrated energy of the transformed coefficients and the compression ratio and data quality. Then, this research shows that sampling details also affect predictions and data compression ratios. Research conducted by Al-Ali, et al. [18], about the use of IoT for Climate-Smart Agriculture (CSA) with a research focus on smart irrigation systems. This research uses solar cell panels as an energy source in developing a smart irrigation system. Distributed solar energy resources can be operated, monitored and controlled remotely. The design of IoT-based solar energy systems for smart irrigation is critical for regions around the world, which face water and electricity scarcity. The proposed system uses a single board system-on-a-chip controller, which has WiFi connectivity, and connection to solar cells to provide the required power. The controller reads the soil moisture, air humidity, and temperature sensors, then issues actuation commands according to the signals to operate the irrigation pump.

Research conducted by Autio, et al. [16] on the challenges of climate uncertainty for the livelihoods of smallholder farmers in sub-Saharan Africa. Awareness of climate-based smart agriculture (CSA) practices and access to climate-based smart technologies are key factors in determining the use of farming and land management practices that can simultaneously reduce greenhouse gas emissions, increase farmers' adaptive capacity, and increase food security. The results of research on the development of the CSA model are very useful for farmers, although there are still limitations related to market mechanisms and land tenure.

Based on these studies, this research will develop a Smart Hydroponic Farming model, to support increasing food security amidst increasingly uncertain climate change. Through the development of the Smart Hydroponic Farming (SHIFA) model, agricultural processes are carried out by utilizing information technology, such as the internet of things (IoT), the use of sensors and an Android-based monitoring system.

2. METHODS

The research method used is the research and development method, with research stages including: literature study, survey and observation, SHIFA system model design as shown in Figure 1, coordination with research partner, hardware and software system requirements analysis, system prototype creation and system testing.

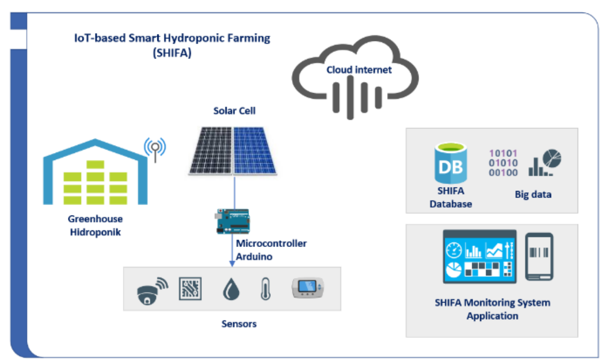

Figure 1 SHIFA Model

Development of the SHIFA system model, using solar cells as energy that will be used in the greenhouse as a test field. The way the system works is starting from the solar cell panel which is connected to the Arduino microcontroller, then reading the sensors, including temperature sensors, humidity sensors, pH sensors and controlling the power source from the solar cells.

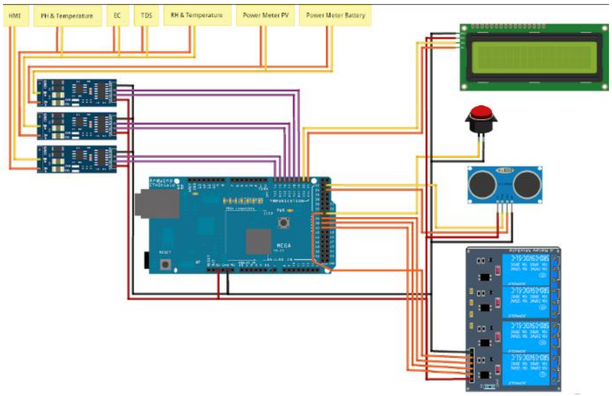

Figure 2 A SHIFA Schematic Diagram

Furthermore, the sensor reading results will be stored in a database, which will produce large data, and can be monitored in real-time on an Android-based monitoring system. A schematic diagram is presented in Figure 2.

The stages of developing a smart hydroponic farming greenhouse monitoring system are as follows in Figure 3, start from design and installation hardware system, designing software and application system, system integration, system testing and evaluation of system testing results.

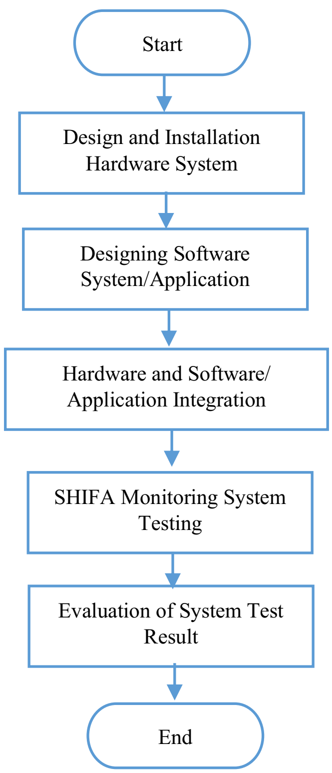

Figure 3 Research Stages Flow Chart

The variables measured are pH, EC, humidity, water temperature, TDS, and air temperature values.

3. RESULTS AND DISCUSSION

In this research, a SHIFA greenhouse with a size of 120 square meters has been built, as shown in Figure 4.

The SHIFA greenhouse is equipped with pH, TDS, EC, humidity, water temperature and air temperature sensors, all of which are connected to the control panel for easy setup, as presented in Figure 4.

Figure 4 SHIFA Greenhouse

How to operate the SHIFA system is as follows.

a) Make sure all sensors are connected and make sure the MCB with the label "PV" is OFF or down.

b) Make sure the "FUSE BATT" condition is open, then attach the battery to the positive and negative poles according to the cable provided and don't turn it upside down. If the battery is installed, the next step is to insert the plug into a 220v electrical socket.

Figure 5 Hardware Control Panel

c) Turn on the AC MCB with the label "mcb", check whether the Mifi and FAN on the device are turned on? If it doesn't turn on then you can check whether the socket has a 220v electricity supply or not, then connect the "FUSE BATT" to the ON position by pushing it in.

d) If it is on, the system is connected properly. If no module or device is on, immediately turn it off or disconnect the "FUSE BATT" current by pulling the tip out because you can be sure there is an error connecting the poles to the battery. Immediately check the polarity of the battery installation and if it has been corrected then connect the "FUSE BATT" to the ON position. Warning: if there is an error in installing the battery poles, it can cause fatal damage to the device.

Furthermore, for the Android-based monitoring system, the Home screen with SHIFA logo is presented in Figure 6.

Figure 6 SHIFA Home Screen

Then the Water Level and Temperature values are displayed on the Android page based on input from the water level and water temperature sensors, as shown in Figure 7.

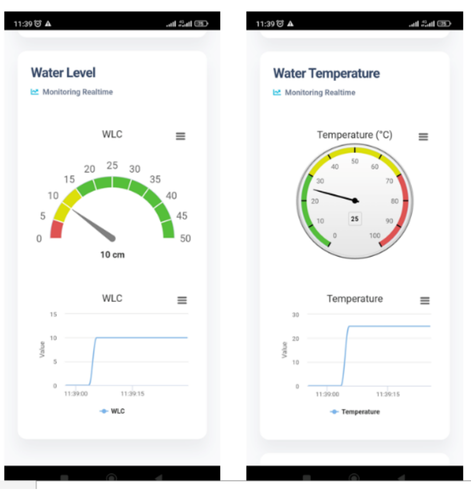

Figure 7 Water Level and Temperature Screen

The Room Humidity and Room Temperature values are displayed on the Android page based on input from the humidity and room temperature sensors, as shown in Figure 8.

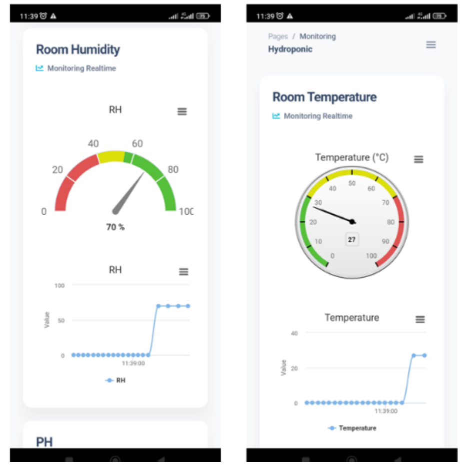

Figure 8 Room Humidity and Temperature

Figure 9 Hydroponic Data Logger

Figure 9 displays the Hydroponic Data Logger which displays measurement time log data, which contains value data from pH, TDS, humidity and temperature sensors.

4. CONCLUSION

In this research, we have succeeded in creating an IoT-based smart hydroponic farming and Android-based monitoring system, which can be monitored online and in real-time from anywhere. The benefit of the proposed innovation for partners is that they could recognize and develop modern agricultural systems, which will have an impact on the increasing number of millennial farmers who understand the digitalization of agricultural systems. Meanwhile, the benefit of innovation for the proposing team is that it can implement knowledge in the IoT field to support agricultural digitalization, and can become a laboratory for students involved in this program, which has an impact on increasing students' knowledge about the development of smart farming. The benefits for universities are achieving KPI through this program, as well as increasing cooperation with partners in the field of agricultural system development, and having an impact on increasing human resource development (lecturers involved), as well as students involved.

AUTHORS' CONTRIBUTIONS

Principal Investigator (Marti Widya Sari): Coordinating research with the research team and partners, mapping hardware and software system requirements, designing web-basaed and Andorid-based monitoring system, and compiling publication articles.

Research Member 1 (R. Hafid Hardyanto): Coordinating with user partners, preparing agricultural land for system trials, and hardware system analysis.

Research Member 2 (Prahenusa Wahyu Ciptadi): Simulated the system before testing it in the field, software system analysis and system integration.

Research Member 3 (Firdiyan Syah): Information system analysis, web-based monitoring system design and web-based monitoring system analysis.

Research Member 4 (Ginanjar Setyo Nugroho): digital marketing surveys, data processing, and documenting research activities.

The Research Team is responsible for developing the Smart Hydroponic Farming system, starting from hardware and software development, integration of hardware and software systems, and implementation of an IoT-based smart farming system. Then the partner is responsible for the greenhouse development process, hydroponic system, land provision, plant nurseries, and agricultural operations.

ACKNOWLEDGMENTS

This research was funded by the 2023 Kedaireka Matching Fund Program, Indonesian Ministry of Education and Culture, Contract Number with Region 5 Higher Education Services Institutions (LLDIKTI 5): 11/E1/HK.02.02/2023 and Higher Education (Universitas PGRI Yogyakarta) Contract Number: 329/BAP-LPPM/V/2023.

REFERENCES

[1] C. M. Musafiri *et al.*, "Adoption of climate-smart agricultural practices among smallholder farmers in Western Kenya: do socioeconomic, institutional, and biophysical factors matter?," *Heliyon*, vol. 8, no. 1, 2022, doi: 10.1016/j.heliyon.2021.e08677.

[2] A. Waaswa, A. O. Nkurumwa, A. M. Kibe, and N. J. Kipkemoi, "Communicating climate change adaptation strategies: climate-smart agriculture information dissemination pathways among smallholder potato farmers in Gilgil Sub-County, Kenya," *Heliyon*, vol. 7, no. 8, p. e07873, 2021, doi: 10.1016/j.heliyon.2021.e07873.

[3] D. Devapal, "Smart Agro Farm Solar Powered Soil and Weather Monitoring System for Farmers," *Mater. Today Proc.*, vol. 24, pp. 1843–1854, 2019, doi: 10.1016/j.matpr.2020.03.609.

[4] J. O. Nyang'au, J. H. Mohamed, N. Mango, C. Makate, and A. N. Wangeci, "Smallholder farmers' perception of climate change and adoption of climate smart agriculture practices in Masaba South Sub-county, Kisii, Kenya," *Heliyon*, vol. 7, no. 4, p. e06789, 2021, doi: 10.1016/j.heliyon.2021.e06789.

[5] Z. Liang, L. Zhang, W. Li, J. Zhang, and L. J. Frewer, "Adoption of combinations of adaptive and mitigatory climate-smart agricultural practices and its impacts on rice yield and income: Empirical evidence from Hubei, China," *Clim. Risk Manag.*, vol. 32, no. April, p. 100314, 2021, doi: 10.1016/j.crm.2021.100314.

[6] I. Pangapanga-Phiri and E. D. Mungatana, "Adoption of climate-smart agricultural practices and their influence on the technical efficiency of maize production under extreme weather events," *Int. J. Disaster Risk Reduct.*, vol. 61, no. June, p. 102322, 2021, doi: 10.1016/j.ijdrr.2021.102322.

[7] M. Hrabanski and J. F. Le Coq, "Climatisation of agricultural issues in the international agenda through three competing epistemic communities: Climate-smart agriculture, agroecology, and nature-based solutions," *Environ. Sci. Policy*, vol. 127, no. April 2021, pp. 311–320, 2022, doi: 10.1016/j.envsci.2021.10.022.

[8] H. Azadi *et al.*, "Rethinking resilient agriculture: From Climate-Smart Agriculture to Vulnerable-Smart Agriculture," *J. Clean. Prod.*, vol. 319, no. August, p. 128602, 2021, doi: 10.1016/j.jclepro.2021.128602.

[9] G. Branca, A. Braimoh, Y. Zhao, M. Ratii, and P. Likoetla, "Are there opportunities for climate-smart agriculture? Assessing costs and benefits of sustainability investments and planning policies in Southern Africa," *J. Clean. Prod.*, vol. 278, p. 123847, 2021, doi: 10.1016/j.jclepro.2020.123847.

[10] C. Yoon, D. Lim, and C. Park, "Factors affecting adoption of smart farms: The case of Korea," *Comput. Human Behav.*, vol. 108, no. February, p. 106309, 2020, doi: 10.1016/j.chb.2020.106309.

[11] M. R. Ramli, P. T. Daely, D. S. Kim, and J. M. Lee, "IoT-based adaptive network mechanism for reliable smart farm system," *Comput. Electron. Agric.*, vol. 170, no. February, p. 105287, 2020, doi: 10.1016/j.compag.2020.105287.

[12] T. Maleki, H. Koohestani, and M. Keshavarz, “Can climate-smart agriculture mitigate the Urmia Lake tragedy in its eastern basin?,” *Agric. Water Manag.*, vol. 260, no. November 2021, p. 107256, 2022, doi: 10.1016/j.agwat.2021.107256.

[13] A. Zakaria, S. B. Azumah, M. Appiah-Twumasi, and G. Dagunga, “Adoption of climate-smart agricultural practices among farm households in Ghana: The role of farmer participation in training programmes,” *Technol. Soc.*, vol. 63, no. August, p. 101338, 2020, doi: 10.1016/j.techsoc.2020.101338.

[14] A. Scognamillo and N. J. Sitko, “Leveraging social protection to advance climate-smart agriculture: An empirical analysis of the impacts of Malawi’s Social Action Fund (MASAF) on farmers’ adoption decisions and welfare outcomes,” *World Dev.*, vol. 146, p. 105618, 2021, doi: 10.1016/j.worlddev.2021.105618.

[15] J. Muangprathub, N. Boonnam, S. Kajornkasirat, N. Lekbangpong, A. Wanichsombat, and P. Nillaor, “IoT and agriculture data analysis for smart farm,” *Comput. Electron. Agric.*, vol. 156, no. December 2018, pp. 467–474, 2019, doi: 10.1016/j.compag.2018.12.011.

[16] A. Autio, T. Johansson, L. Motaroki, P. Minoia, and P. Pellikka, “Constraints for adopting climate-smart agricultural practices among smallholder farmers in Southeast Kenya,” *Agric. Syst.*, vol. 194, no. September, p. 103284, 2021, doi: 10.1016/j.agsy.2021.103284.

[17] A. Moon, J. Kim, J. Zhang, and S. W. Son, “Evaluating fidelity of lossy compression on spatiotemporal data from an IoT enabled smart farm,” *Comput. Electron. Agric.*, vol. 154, no. September, pp. 304–313, 2018, doi: 10.1016/j.compag.2018.08.045.

[18] A. R. Al-Ali, A. Al Nabulsi, S. Mukhopadhyay, M. S. Awal, S. Fernandes, and K. Ailabouni, “IoT-solar energy powered smart farm irrigation system,” *J. Electron. Sci. Technol.*, vol. 30, no. 40, pp. 1–14, 2020, doi: 10.1016/J.JNLEST.2020.100017.