

## Control and Automation: Insmoaf (Integrated Smart Modern Agriculture and Fisheries) on The Greenhouse Model

### (Kontrol dan Otomatisasi: Insmoaf (*Integrated Smart Modern Agriculture and Fisheries*) pada Model Rumah Kaca)

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#### ABSTRACT

A greenhouse is an agricultural management system that has shown the efficiency of food production. This system is an effective alternative to ensure maximum production results. Agriculture with greenhouse technology can create the desired environmental/climatic conditions. The rapid development of technology and science has led to the birth of communication between devices using IoT and AI. This technology can be applied to greenhouses in agriculture and fisheries. Research on greenhouse and microcontroller-based automation systems has been carried out, and it is interesting to be developed. Researchers make a more efficient system and can increase the quality and quantity of production. The measurement data of both modes are monitored using the web. The greenhouse prototype is supported by DHT22, DS18B20, a fan to control the greenhouse cooler, RFID as the key access to the greenhouse. DHT22 & DS18B20 sensor readings in the prototype greenhouse use an AI system with the fuzzy method. IoT and AI have been successfully implemented in models of rice fields, hydroponic farming, and fisheries using automatic modes of RTC devices and sensors. The fuzzy approach method is used to find the optimum temperature and humidity values. The fuzzy approach was successfully carried out until the temperature and humidity conditions were "ideal," "high," and "very high." This condition provides information to the microcontroller to activate which fan should turn on. In manual mode, the smartphone application controls the system properly.

**Keywords:** artificial intelligence, control and automation, fuzzy logic, greenhouse, IoT

#### ABSTRAK

Rumah kaca merupakan salah satu sistem pengelolaan pertanian yang telah menunjukkan efisiensi produksi pangan. Sistem ini merupakan alternatif yang efektif untuk memastikan hasil produksi yang maksimal. Pertanian dengan teknologi rumah kaca dapat menciptakan kondisi lingkungan (iklim) yang diinginkan. Pesatnya perkembangan teknologi dan ilmu pengetahuan telah melahirkan komunikasi antarperangkat yang menggunakan IoT dan AI. Teknologi ini dapat diterapkan pada rumah kaca di bidang pertanian dan perikanan. Sistem otomatisasi berbasis rumah kaca dan mikrokontroler telah banyak diteliti dan menarik untuk dikembangkan. Peneliti membuat sistem yang lebih efisien dan dapat meningkatkan kualitas dan kuantitas produksi. Data pengukuran kedua mode dipantau menggunakan web. Prototipe rumah kaca ini didukung oleh DHT22, DS18B20, kipas untuk mengendalikan pendingin rumah kaca, dan RFID sebagai kunci akses ke rumah kaca. Pembacaan sensor DHT22 & DS18B20 pada prototipe rumah kaca menggunakan sistem AI dengan metode fuzzy. IoT dan AI telah berhasil diimplementasikan pada model persawahan, pertanian hidroponik, dan perikanan menggunakan mode otomatis perangkat dan sensor RTC. Metode pendekatan fuzzy digunakan untuk mencari nilai suhu dan kelembapan yang optimal. Pendekatan fuzzy berhasil dilakukan hingga kondisi suhu dan kelembapan "ideal," "tinggi," dan "sangat tinggi." Kondisi ini memberikan informasi kepada mikrokontroler untuk mengaktifkan kipas mana yang harus dihidupkan. Dalam mode manual, aplikasi smartphone mengendalikan kontrol sistem dengan baik.

**Kata kunci:** kecerdasan buatan, kontrol dan otomatisasi, logika fuzzy, rumah kaca, IoT

#### INTRODUCTION

Advances in information technology and embedded systems in the digitalization era are increasingly leading to studies of control systems, automation, IoT, and artificial intelligence. Research in this field, especially the topic of greenhouse in agriculture and fisheries, automation of hydroponic agriculture, automatic watering of rice fields, feeding of fish based on microcontrollers, is exciting to review, as was done by previous researchers (Cobantoro *et al.* 2019; Syah *et al.* 2018; Putri *et al.* 2019; Sutiawan *et al.* 2020;

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Sutikno and Khotib 2019; Marzuki and Wicaksono 2019; Rahmawati 2019; Sujadi and Nurhidayat 2019; Wulansari and Setyawati 2019; Saraswathi *et al.* 2011; Meili and Yankang, n.d.; Sung *et al.* 2017; Pitakphongmetha *et al.* 2016; Miranda *et al.* 2019; Siskandar and Kusumah 2019).

Greenhouse farming is an agricultural management system that has shown efficiency in intensifying food production. This system is a safe and viable alternative to ensuring a food supply, one of the most significant challenges facing humanity in the 21st century (Aznar-Sánchez *et al.* 2020). Technology has been able to meet the challenges associated with greenhouse farming in overcoming its limitations, correcting adverse effects, and ensuring the system's sustainability (Ferentinos *et al.* 2015; Meili and Yankang, n.d.; Lamprinos *et al.* 2015).

The rapid development of technology and science has led to the birth of the 4.0 industrial revolution, which prioritizes communication between devices using IoT and AI. IoT is one of the main elements in the development of this revolution. IoT utilization in agriculture can be applied to greenhouse technology (Kusuma *et al.* 2019; Sujadi and Nurhidayat 2019; Saraswathi *et al.* 2011). A greenhouse is a building that creates suitable environmental conditions for plant growth and maintenance. In his research, Sujadi and Nurhidayat (2019) explained that the application of IoT in greenhouse technology can monitor temperature, humidity, soil moisture, watering, and fertilizing plants automatically, in real-time, and can control plants remotely. AI is a simulation of human intelligence carried out by machines and programmed by humans. Machines must learn to reason and self-correct as needed over time (Benyezza *et al.* 2018; Pourjavah and Shahin 2018). Agriculture with greenhouse technology can create the desired environmental (climatic) conditions. With this technology, plant maintenance will certainly avoid unfavorable conditions, such as too low temperature and high rainfall. One of the cultivation techniques applied in greenhouse technology is agricultural cultivation (rice field and hydroponic models) and aquaculture.

Cultivation is a planned activity to maintain biological resources carried out on land to take advantage of harvest results. Fishery cultivation is an effort to maintain and breed fish or other aquatic organisms. The success of freshwater fish farming is primarily determined by the environment, namely temperature, pH, and oxygen. Therefore, environmental quality must always be a concern so that freshwater fish farming can be optimal. Apart from environmental conditions, the feed factor is also an essential factor in the success of fish farming, so the feeding schedule must be considered (Humaerah 2013; Boonnam *et al.* 2020; Rahayu *et al.* 2018; Borstel *et al.* 2013; Sung *et al.* 2017; Mccoy *et al.* 2017; Siregar and Ginting 2017; Miranda *et al.* 2019; Meijide *et al.* 2016; Kusuma *et al.* 2019; Benyezza *et al.* 2018; Siskandar and Kusumah 2019).

According to BPS data, the rapid population growth rate of 1.94% per year (more than 237 million people in 2010) has resulted in an increasing need for rice. Meanwhile, the production growth is not proportional to the demand, even slopes. Moreover, high population growth rates also affect land requirements for non-agricultural purposes such as housing, shopping centers, industry, or other public facilities such as elevated roads, toll roads, etc. As a result, the conversion of agricultural land to non-agricultural land has become increasingly difficult to control (Humaerah 2013).

Meili and Yankang (n.d.) designed an automatic control system based on temperature, humidity, and light intensity of agricultural greenhouses. This system's advantages are that the system is quite simple in operation, low cost, and high precision. This system's weakness is that the DHT11 sensor only has a humidity range of 20–80% with an accuracy of 5%, so the humidity measurement range is not adequate; the monitoring system cannot be done remotely. Lamprinos *et al.* (2015) in his paper presents the features of implementing a wireless network-based greenhouse monitoring system. The system consists of various sensor nodes that collect environmental condition data and send it to a remote database. The advantage of this system is that it can explore the level of heterogeneity in microclimate conditions in the greenhouse environment; farmers can monitor greenhouse conditions through the web. This system's disadvantages are that the system is only applied to one agricultural model (tomato cultivation); farmers cannot control the system remotely.

Chaudhary *et al.* 2011 in his paper presents that technological developments in wireless sensor networks allow it to be used in monitoring and controlling greenhouse parameters in precision agriculture. The advantages of this system are: utilizing greenhouse technology as the best solution to overcome weather prediction problems that are unpredictable by farmers. On the other hand, the weaknesses of this system are: the system cannot control the situation if the four parameters do not meet the wishes of the farmers; monitoring parameter data has not used the intelligence system method.

Based on the above background, we took a study entitled "Control and Automation: Insmoaf (Integrated Smart Modern Agriculture and Fisheries) on The Greenhouse Model." The purpose of this study is to develop a system that can facilitate the work of farmers in time and energy efficiency to improve the quality and quantity of agricultural production (paddy field and hydroponic models) and aquaculture in greenhouses. The innovation and novelty of the inSmoAf system are: the system is applied to greenhouse technology which is integrated with agriculture and fisheries models. The system uses two modes in each prototype model: automatic mode and manual mode (control using a smartphone). Data from both modes of work measurement can be monitored using the web. The

greenhouse prototype is supported by temperature sensors (DHT22 and DS18B20) and humidity (DHT22) that have a better measurement range than DHT11, namely 0–100% with an error of 2–5%), hexos fan to control greenhouse coolers, RFID as access keys to enter the greenhouse. The temperature and humidity reading in the prototype greenhouse uses an AI system with a fuzzy method. The aim is to get the right temperature and humidity values to support improving the quality and quantity of agricultural and fishery production products.

## RESEARCH METHOD

### General

This article describes the experimental research conducted at the Hardware Laboratory, Vocational School of IPB University, from August to December 2020. The materials and tools used in the research included materials and tools for assembling prototype models of greenhouses, materials, and tools for prototyping rice fields models, materials, and tools. For building prototype models of hydroponic models and materials and tools for making prototype models of fish ponds.

### InSmoAf System Design and Evaluation on The Greenhouse Model

We developed inSmoAf in the greenhouse model into three models: rice field farming, hydroponic farming, and fish ponds. The model was designed in two modes, namely automatic and manual. In principle, the systems in each model were integrated. The automatic mode function of each model was

determined from the sensor readings and the predetermined timing conditions. Meanwhile, the manual mode worked when the automatic mode was not activated. The readings made by temperature & humidity sensors on the prototype model greenhouse used an AI system with a fuzzy method to get the correct value to support the increase in the quality and quantity of cultivation products. From the description above, "Control and Automation: inSmoAf on The Greenhouse Model" updates greenhouse technology in integrated agriculture. We also evaluated a greenhouse technology model using use case analysis (El-madbouly and Hameed 2017; Nasution *et al.* 2020; Manríquez-Altamirano *et al.* 2020; Sujadi and Nurhidayat 2019; Meili and Yankang, n.d.; Balaine *et al.* 2019; Lamprinos *et al.* 2015; Benyezza *et al.* 2018; Boonnam *et al.* 2020; Rahayu *et al.* 2018; Chaudhary *et al.* 2011). The general in SmoAf on the greenhouse model solution design is shown in Figure 1.

### InSmoAf Mechanism Design

Figure 2 shows the overall diagram of the inSmoAf system, which is easier to understand. This research was developed to help farmers remotely monitor agriculture and fisheries mechanisms in greenhouses and create a security system when users are far from the place. There were two modes to choose from: an automatic mode that works based on sensor readings and the set time setting conditions; and a fully manual mode that works on orders from clients via smartphones. Each mode in each prototype model was processed by a microcontroller (NodeMcu). This experiment also developed fuzzy logic on the DHT22 sensor reading (the greenhouse prototype model). This fuzzy method was developed to get the right

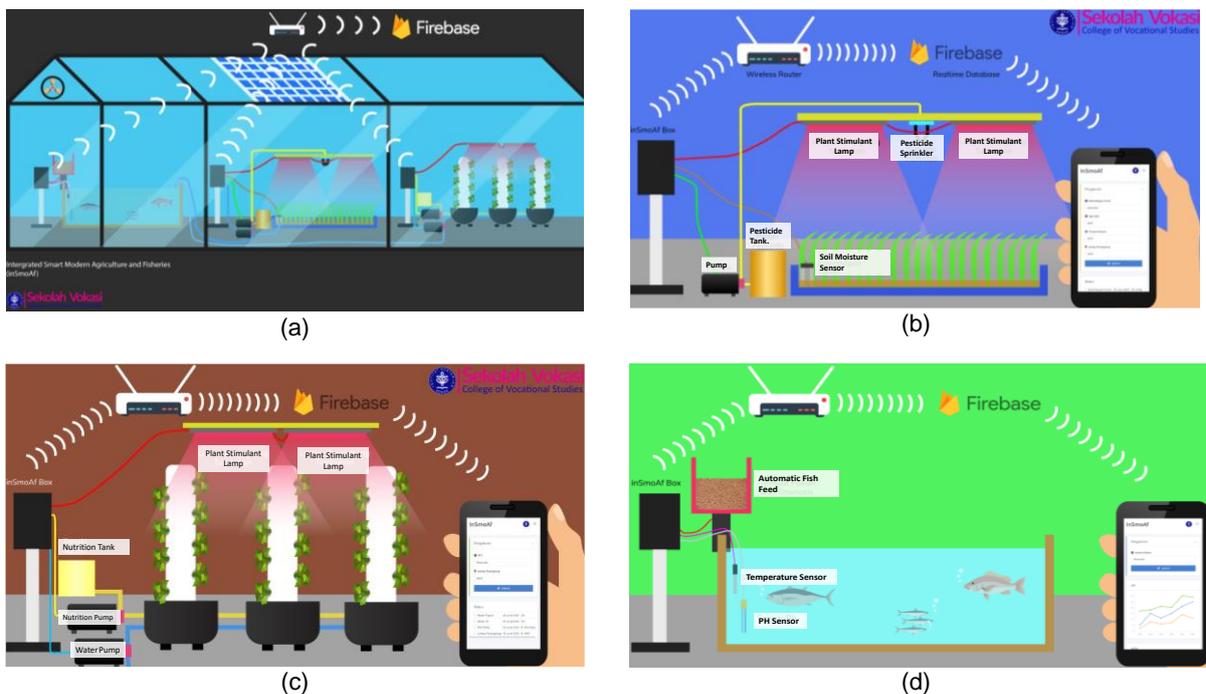


Figure 1 General inSmoAf on the greenhouse model solution design: (a) model greenhouse; (b) rice field model; (c) hydroponic model; and (d) fish pond model.

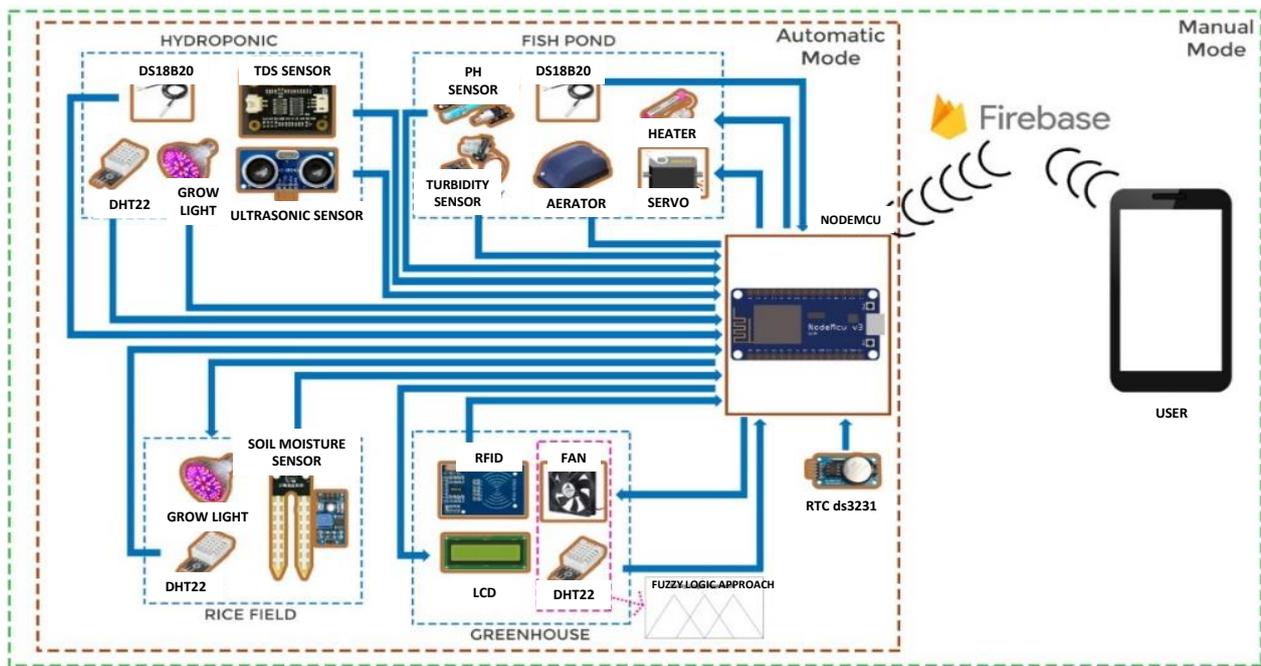


Figure 2 InSmoAf overall system diagram.

temperature and humidity values (each model has an optimum temperature and humidity limit).

**Fuzzy Method**

Fuzzy thinking logic is used in the prototype greenhouse to control room temperature and humidity. The sensor then reads the results of the defuzzification to determine the length of time the exhaust fan turns on so that the temperature and room are in ideal conditions. The output variables resulting from the defuzzification results were the temperature and humidity of the greenhouse control room.

Fuzzy logic design was divided into three parts, namely the determination of the membership set, fuzzy rule-based, and the defuzzification process (Maghfiroh *et al.* 2020; Keykavoussi and Ebrahimi 2018; Ahmad and Moamin 2018; Hu *et al.* 2019; Zhou *et al.* 2016; Santosa *et al.* 2020; Husen *et al.* 2020; Pourjavad and Shahin 2018). In this work, the fuzzy logic design was used to determine the length of time the exhaust fan works by each treatment's temperature and humidity conditions.

**RESULTS AND DISCUSSION**

The following implementation explains the general description of the inSmoAf on the greenhouse model, which is shown in Figure 3. It describes the prototype model of the greenhouse; there are prototype model for rice fields, hydroponic farming, and fish ponds.

The results of the temperature and humidity sensor readings (fuzzy method approach) are used as a control (to activate) the fan; The RTC functions as a control for predefined timing conditions. For example, RTC is used to turn on (17.30–05.30 WIB) and turn off



Figure 3 The greenhouse model.

(05.31–17.29) grow light (rice field and hydroponic models); hexos fan functions as an output that works when getting commands from the reading of the temperature and humidity sensors; and RFID functions as a security for the entrance to the greenhouse. The solenoid (key to the greenhouse door) opens if the RFID card is registered, and the LCDs "Access Granted." If the identity is not registered, the solenoid (key to the greenhouse door) is locked and the LCDs "Access Denied." The access success/failure display is shown in Figure 4.

In the rice field model, the soil moisture sensor reads the dry/wet conditions of the planting medium (35% for dry conditions, 45.5% for humid conditions, and 62.2% for wet conditions) (Kumar *et al.*, n.d.; Balaine *et al.* 2019); RTC is used to adjust the timing of the on/off the output of the pesticide pump (08.00 and 16.00 hours); and a water pump as an output that works according to the soil moisture sensor readings. The hydroponic farming model is equipped with a vertical hydroponic pipe that functions as a planting medium; RTC functions as a sprinkler timer (07.30 and 16.30); nutrition sensor as a nutrition reading sensor; ultrasonic sensor as water level reading sensor; and two water pumps as output which work according to the readings of the ultrasonic sensor and nutrient sensor. The fish pond model is equipped with a water pH

sensor, oxygen sensor, and water temperature & humidity sensor, which has their respective functions to read the conditions of pH, oxygen, and water temperature & humidity in the fish pond; RTC functions as a timer for automatic feeders (06.00, 09.00, 12.00, 15.00, 18.00). The frequency of daily fish feeding was done five times, with a time interval of 3 hours and servo as output (motor drive opens/closes the fish feed cover).

**Fuzzy Logic Approach**

The trapezoidal type of fuzzy membership set approach is used to control the temperature in the greenhouse by comparing the actual conditions to get the ideal temperature in the greenhouse (Márquez-Vera *et al.* 2016). The fuzzy logic consists of two variables from each prototype model, namely variable temperature and variable humidity. The fuzzy logic of the sensor readings is used to process temperature data in the greenhouse to activate the exhaust fan for ideal room conditions (Argo *et al.* 2019). In this study, to determine the greenhouse's ideal temperature and humidity conditions. We used the temperature and humidity control defuzzification values to determine the length of time the exhaust fan was on. The temperature and humidity membership sets for each treatment were made using the Matlab application. The membership set of the input and output temperature variables of each treatment is shown in Figure 5. At the same time, the membership set of the humidity input and output variables of each treatment is shown in Figure 6.

The membership set of temperature and humidity results produce a *fuzzy rule base* that applies to each treatment. A *fuzzy rule base* is used to determine the fuzzy value for temperature and humidity control using the "and" operator. Anfis If Than Else The temperature and humidity control rules are shown in Figure 7.

The results of the fuzzy membership set in Figure 7 show the characteristics of the temperature and humidity variables for each treatment at the greenhouse. The "If Then Else Rule" results are used to determine the temperature and humidity control values through the defuzzification process. The characteristics of the temperature and humidity control "surface of Anfis" are shown in Figure 8.

**Automation Module Use Case Analysis**

At this stage, each prototype model has a microcontroller circuit (NodeMCu) equipped with a tool component called RTC (type DS3231). Testing of electronic circuits for RTC was done by uploading a timing program to NodeMCu. The series aims to determine whether the timing of each function is running correctly following the predetermined time. The electronic circuit test results for the RTC are shown in Table 1.

Apart from the RTC, another critical component in the automation module is sensor components. A sensor is an input device that provides an output

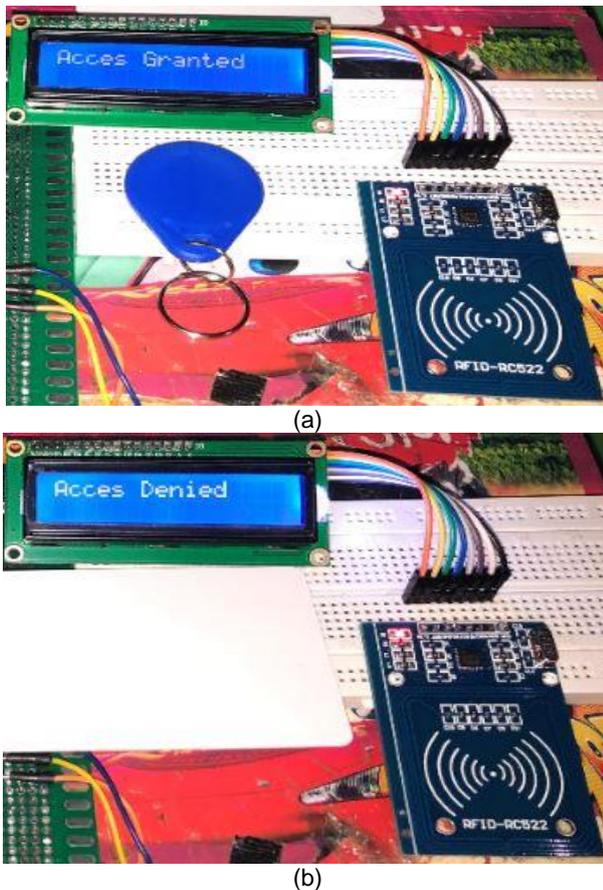


Figure 4 Display LCD: (a) Access granted and (b) Access denied

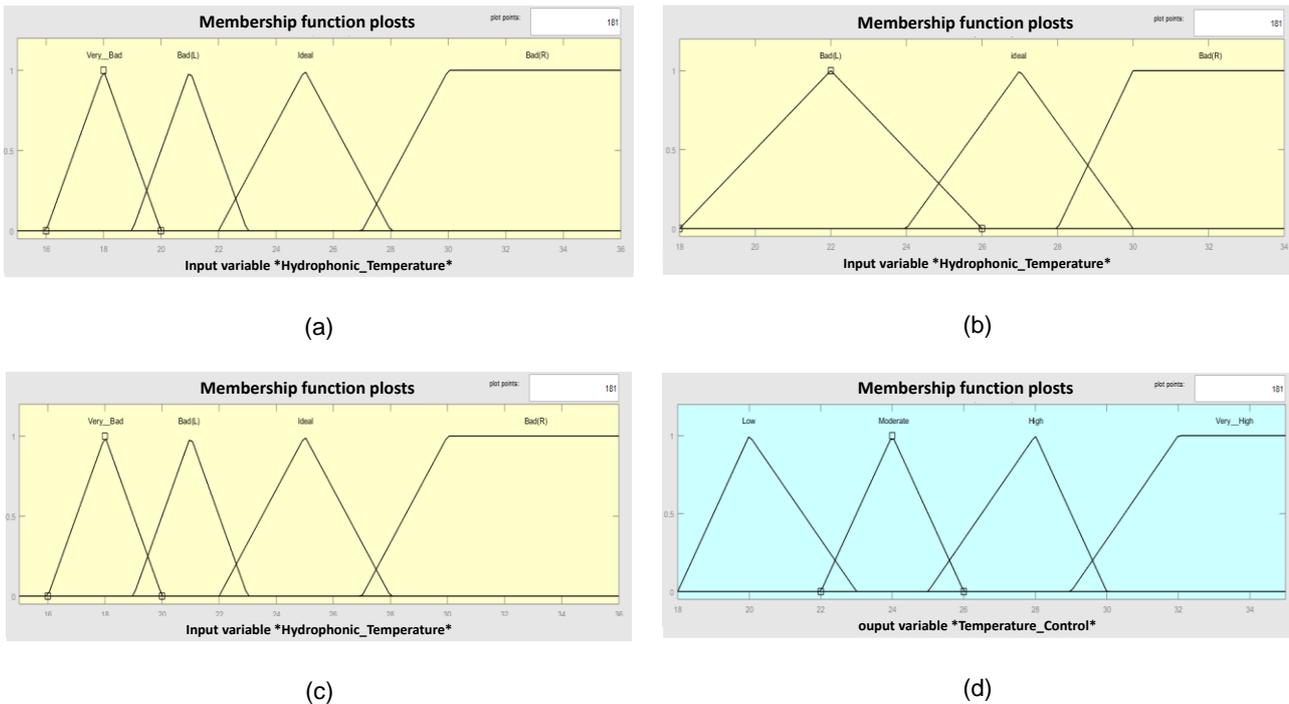


Figure 5 Membership sets of temperature input and output variables: (a) Rice Field temperature (Input Variable); (b) Hydroponic temperature (Input Variable); (c) Fish Pond temperature (Input Variable); and (d) Temperature control (Variable Output).

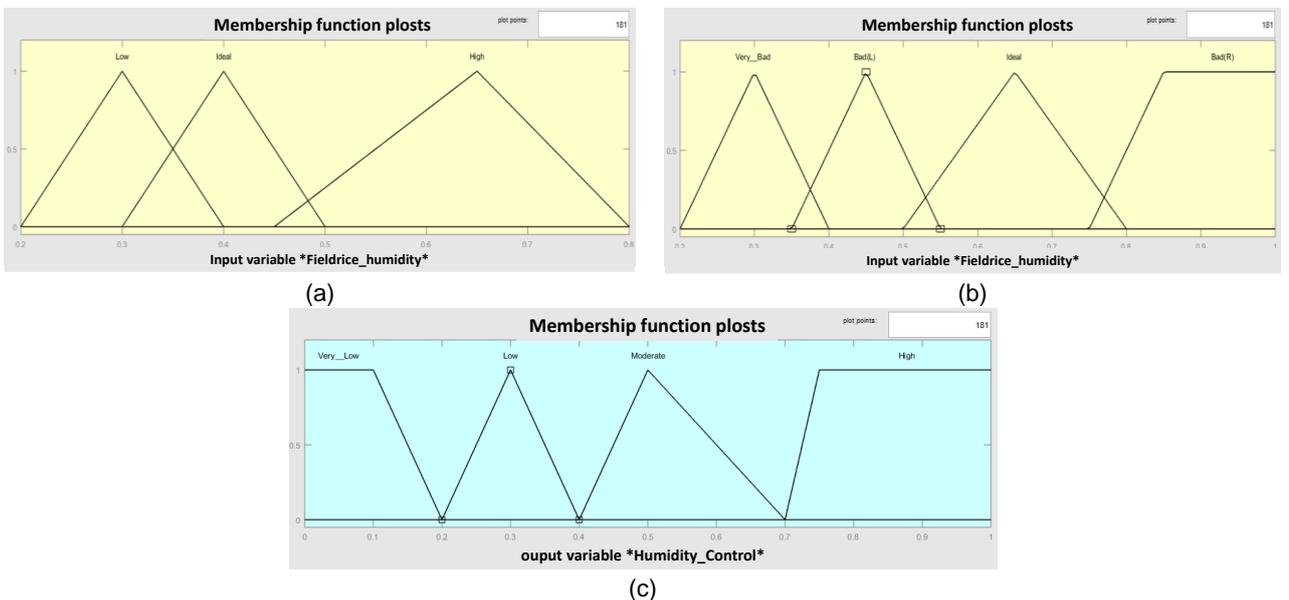


Figure 6 Membership set of input and output humidity variables: (a) rice field humidity (variable input); (b) hydroponic humidity (variable input); and (c) humidity control (variable output).

(signal) concerning a particular physical quantity (input). The term "input device" in the definition of a sensor is that part of a larger system that provides input to the primary control system (Nasution *et al.* 2020). The results of testing the fuzzy model on the temperature and humidity output values were used to determine the control conditions of these two variables. Each repetition value was the average result of the sensor readings every 1 minute for 1 hour.

The measurement results of the tool (in each model) against the measurement results of conventional tools (thermometer and hygrometer) have an accuracy of above 95%. Defuzzi (temperature and humidity values) was obtained from the results of the approach using the fuzzy method. The defuzzification value of the output variable was then used as a performance controller for the fan in the greenhouse model prototype. The length of time the fan works was determined from the input of temperature and humidity values from the

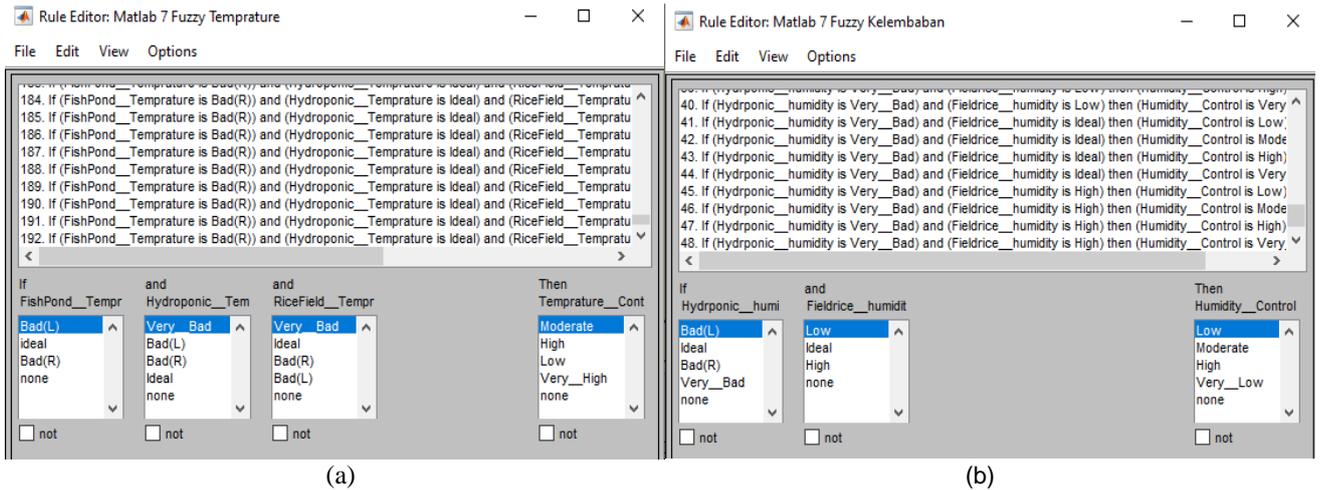


Figure 7 Anfis if than else rule: (a) Temperature control; (b) Humidity control.

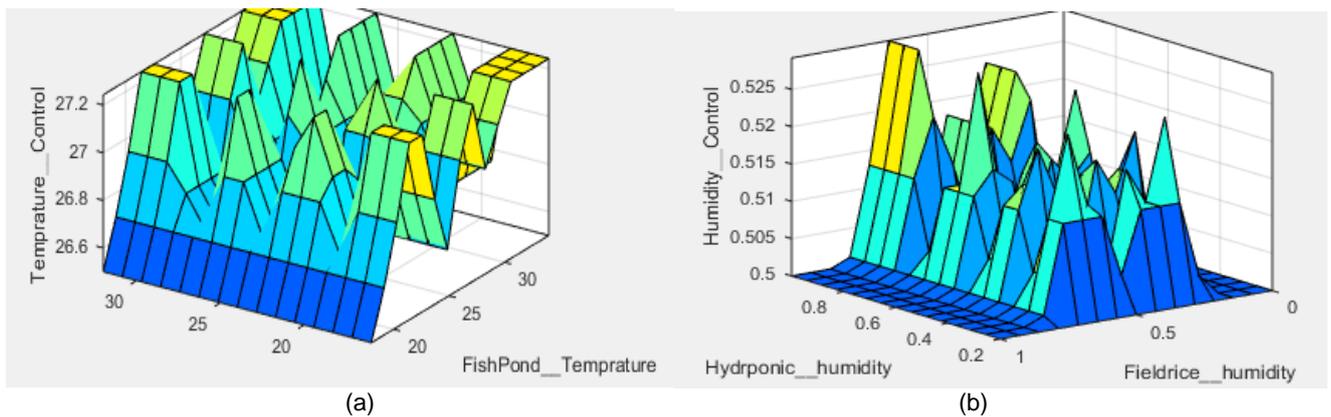


Figure 8 Surface of anfis controller: (a) Temperature control and (b) Humidity control.

Table 1 Test results for electronic circuits (RTC)

Used of RTC	Time (hour)	Grow Light Condition	The Grow Light Voltage Output (volt)	Information
Greenhouse model prototype	07.00	Off	0.2	According to Expectations
	18.00	On	5.0	According to Expectations
	04.30	On	5.0	According to Expectations
Rice field prototype	Time (hour)	Pesticide Pump Condition	The Output Voltage of The Pesticide Pump (volt)	Information
	08.00	Active	5.0	According to Expectations
	12.00	Non-active	0.2	According to Expectations
	16.00	Active	5.0	According to Expectations
Hydroponic model prototype	Time (hour)	Watering Pump Condicion	The Output Voltage of The Nutrition Pump (volt)	Information
	07.30	Active	5.0	According to Expectations
	12.00	Non-active	0.2	According to Expectations
	16.30	Active	5.0	According to Expectations
Fish pond model prototype	Time (hour)	Fish Feed Cover Condition	Servo Voltage Output (volt)	Information
	06.00	Servo on	5.0	According to Expectations
	09.00	Servo on	5.0	According to Expectations
	10.00	Servo off	0.2	According to Expectations
	12.00	Servo on	5.0	According to Expectations
	15.00	Servo on	5.0	According to Expectations
	18.00	Servo on	5.0	According to Expectations

defuzzification of the temperature and temperature controls. The fan consisted of 4 pieces that work based on the conditions of the resulting temperature and humidity controls. The light fan (F) rule is shown in Table 2. Based on the light exhaust fan rule, the resulting temperature and humidity are grouped into the normal, high, and very high status to determine the fan that turns on in that condition. The temperature and humidity tests based on the defuzzification value are shown in Table 3. It shows that high temperatures affect the effectiveness of fan performance which is getting longer. Besides, the higher the temperature, the more fans are working (> 1 fan). This is regarding the relationship between exhaust fan conditions based on fuzzy control values.

The value of the soil moisture sensor reading on the rice field prototype model was used to determine the performance of the water pump. Soil is said to be dry if  $950 < \text{soil moisture bit value} \leq 1023$ , moist soil if  $650 < \text{soil moisture bit value} \leq 950$  and wet soil if  $100 < \text{soil moisture bit value} \leq 650$  (Siskandar *et al.* 2020; Latif and Megantoro 2020; Nasution *et al.* 2020). The water pump releases water if the planting medium (soil) is dry. More specifically, the results of the soil moisture sensor test are shown in Table 4.

The hydroponic model prototype is also equipped with a total dissolved solids (TDS) sensor and an

ultrasonic sensor. The TDS sensor controls the adequacy of nutrients in a container for the mixture of nutrients + water. The ultrasonic sensor is used to control the adequacy of water in the mixture of nutrients + water. Ideally, the mixed nutrient and water mixture has a value of 1040–1400 ppm for kale and mustard greens (Saraswathi *et al.* 2011; Pitakphongmetha *et al.* 2016; Siregar and Ginting 2017). When the mixed nutrient + water bath shows a nutritional value <1040 ppm, the solenoid valve is open. The nutrients from the nutrient storage tub flow into the nutrient storage tub + water until the nutritional value is  $\leq 1400$  ppm. When the mixed nutrient + water bath shows a nutritional value of > 1400 ppm, the solenoid valve is closed, while the solenoid valve (fish pond) is open so that the water from the fish pond flows into the nutrient reservoir + water until the nutritional value is in the range of 1040–1400 ppm. Besides, if the mixed nutrient + water bath shows a water level  $\leq 5$  cm, the solenoid valve is open so that the water from the fish pond will flow into the nutrient + water reservoir to a height of 15 cm. The test results of the TDS sensor and ultrasonic sensor on the pump are shown in Table 5.

The results of testing the pH sensor and turbidity sensor on the fish pond model prototype are shown in Table 6. A good pH value for fish ponds is in the range

Table 2 Exhaust fan condition based on fuzzy control value

Temperature	Humidity		
	Ideal (HI)	High (HH)	Very high (HVH)
Ideal (TI)	Off	F2	F2,F3
High (TH)	F1	F1, F2	F1, F2, F3
Very High (TVH)	F1, F2	F1, F2,F3	F1, F2, F3, F4

Table 3 Exhaust fan control test results against temperature and humidity fuzzy control values (Deffuzy)

Temperature (oC)	Deffuzification (Control)		Performance Fan 1		Performance Fan 2		Performance Fan 3		Performance Fan 4		
	Status	Humidity (%)	Status	Time (sec)	Condition	Time (sec)	Condition	Time (sec)	Condition	Time (sec)	Condition
26.7	Ideal	50.5	Ideal		Off		Off		Off	-	Off
26.9	Ideal	51.1	Ideal		Off		Off		Off	-	Off
26.7	Ideal	51.6	High		Off	180	On		Off	-	Off
27.0	High	51.1	Ideal	60	On		Off		Off	-	Off
26.9	Ideal	51.9	High		Off	190	On		Off	-	Off
27.5	Very High	51.7	High	30	On	186	On	14	On	-	Off
26.9	Ideal	53.1	Very High		Off	190	On	34	On	-	Off
26.9	Ideal	50.8	Ideal		Off		Off		Off	-	Off
27.0	High	51.4	High	60	On	176	On		Off	-	Off
27.1	High	50.6	Ideal	62	On		Off		Off	-	Off

Table 4 Moisture sensor test results against water pump

Repeat to	Soil type	Soil moisture sensor value (bit)	Value of output voltage (volts)	Water pump
1	Wet	150	0.7	Turn off
2		256	1.2	Turn off
3		560	2.7	Turn off
1	Moist	683	3.3	Light up
2		693	3.3	Light up
3		718	3.4	Light up
1	Dry	950	4.6	Light up
2		1014	4.9	Light up
3		992	4.8	Light up

of 6.5–8.5. This range is the optimum range for fish health. Stabilizing the pH condition of the fish pond lime is usually given if the pH is too acidic, on the contrary, if the pH is too alkaline, fermentation is given/add ketapang leaves (Sung *et al.* 2017). The value of water turbidity in fish ponds also significantly affects fish health. The value of water turbidity in a good fish pond is not more than 50 NTU. If the water is too dirty, fish farmers usually do the filter, sediment, or change the water (Mccoy *et al.* 2017). In this study, the pH conditions and water turbidity conditions in the pond were set in the range of values 6.5–8.5 for pH and not more than 50 NTU for the water turbidity. It is found that the value of the tool's accuracy for the pH sensor and the turbidity sensor is 97.3% and 99.0%, meaning that that the tool are successful.

**Smartphone Module Use Case Analysis**

In this study, smartphones were used to change automatic mode to manual mode (control by smartphone) or vice versa through an application

system anytime and anywhere. Manual mode is activated if the automatic mode is not activated. Automatic mode reactivates if manual mode via apps is turned off. Figure 9 (a) shows the display changing from automatic to manual mode on the smartphone application. Figure 9(b) shows the condition of NodeMCU connected to the access point. When the system is in manual mode, the RTC and sensors will not function because the complete control of the greenhouse system is with the client. The test results show that the system is entirely manual when NodeMCU is connected to the access point. IP server, which shows that it is connected, is 192.168.43.118.

**CONCLUSION**

The design of IoT and AI on control and automation system devices: inSmoAf (Integrated Smart Modern Agriculture and Fisheries) on The Greenhouse has been successfully constructed for rice field farming

Table 5 Total dissolved solids (TDS) sensor test results and ultrasonic sensor of pump

Sensor value TDS (ppm)	Sensor value ultrasonic (cm)	Solenoid valve, nutrient container	Solenoid valve fish pond
1021	5.0	Open	Open
1270	10.0	Open	Closed
1560	15.0	Closed	Closed
1440	5.0	Closed	Open

Table 6 Test results of pH and turbidity sensors against solenoid valve

Hour	pH Sensor Tool	Digital Water pH	Turbidity Sensor Tool (NTU)	Turbidity Meter SGZ200BS (NTU)
09.00	6.9	6.7	48.0	48.5
12.00	6.8	6.8	48.0	49.2
15.00	6.7	6.6	49.0	49.5
18.00	6.7	6.5	45.0	46.3
21.00	7.1	6.9	40.0	39.7
00.00	7.2	6.9	38.0	37.9
03.00	7.2	6.9	37.0	37.3
06.00	6.9	6.7	44.0	44.3



(a)



(b)

Figure 9 (a) Display changing inSmoAf system mode on smartphone application and (b) IP display condition of NodeMCU connected to access point.

models, hydroponic farming models, and fish pond models using automatic mode and manual mode. Manual mode is activated if the automatic mode is not activated. Automatic mode reactivates if manual mode via the app is turned off. The test results show that the system is entirely in manual mode when the NodeMCU is connected to the access point. The server ip that shows it is connected is 192.168.43.118. The fuzzy approach was successfully carried out until the "ideal," "high," and "very high" conditions of temperature and humidity were obtained. This condition provides information to the microcontroller to activate which exhaust fan should turn on. The radio frequency identification (RFID) system for greenhouse doors (solenoids) can open if the RFID card ID is registered. However, if the RFID card ID is not registered, the door (solenoid) remains closed. The relationship between the TDS sensor data reading and the ultrasonic sensor to the Water pump activation has worked as expected. The pump releases water when the planting medium (soil) is dry. The water quality data measured by the system is in the value range of 6.5–8.5 for pH and not more than 50 NTU for water turbidity.

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