User Acceptance for Multitask IoT Monitoring and Controlling System for Salt Ponds

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Abstract. The process of making salt is still done manually by filling water into reservoirs and plots which require salt farmers to visit their farms periodically. This is mainly because the speed of the salt crystalization process is always inconsistent due to salt concentration in seawater and the weather. This study aims to build a new prototype of a water level monitoring system in reservoirs and plots in salt ponds then measure the water's salinity value, which will be reported to the farmers. The method used in this research is prototyping, which includes system requirement analysis, rapid design, prototype building, system evaluation, and system improvement. The system was tested using the black box method, namely testing all system functionality and determining user satisfaction with questionnaires. The functionality test results, including monitoring the water level and the pump control, show that the prototype functions correctly. The designed system can send information in the form of water level values in reservoirs, water levels in plots, and salinity values with linear sensor accuracy with measurement results with conventional measuring instruments with standard error values of 0.485, 0.44, and 0.72, respectively. Applying this system will ease farmers' monitoring of water levels and controlling irrigation in reservoirs and plots.

Keywords: salt farmer, irrigation in reservoir, monitoring, controlling, Android.

1. Introduction

Salt is one of the essential needs in the daily life of Indonesian people. Salt making in Indonesia is mostly done traditionally by salt farmers because of the traditional tools and ways to monitor the process of salt making. Salt-making is widely produced in various cities in Indonesia, especially in eastern Indonesian coastal towns which have low rainfall [1]. One of them is Pati, Central Java. Pati is well known for producing salt, which contributes at least 350,000 tons to national salt production yearly [2], which ranks second after Madura as the city which produces most salt in Indonesia [2, 3]. In salt-making, the irrigation process in salt ponds must be carried out continuously and periodically because seawater is the main component. Salt production requires media in the form of ponds as reservoirs filled with seawater, salt plots to increase the concentration of seawater, and table salt for the salt crystallization process, which takes an average of 4-5 days. This process requires periodic checks of the pond to see the water level in the salt ponds and reservoirs. Farmers monitor irrigation in salt ponds by coming directly to the location regularly. If the water in the reservoir and the plots is reduced or depleted, the farmer will fill the water using a diesel pump or by pumping water using a pump hose. However, salt farmers in Pati are still doing all of the processes manually, thus resulting in less effective and less efficient methods because farmers have to spend more time and effort only monitoring the water level in ponds periodically. Therefore, farmers need to control the water flow to the ponds remotely.

Previous research on monitoring water levels using IoT devices, such as Arduino, is more effective than measuring it manually [4, 5, 6, 7, 8]. The user of the systems from various backgrounds can get the data on the water level using various devices and methods on their ends, such as websites [6, 9], email notifications [7], or SMS [5]. This system can also be already applied to various places, like water tanks [10, 6, 8], fish ponds [11, 5], rice fields [4], and rivers [7, 12].

Ulumuddin, et al [6], Shankar and Dakshayini [10], and Irvawansyah and Rahmansyah [8], created a water level monitoring system for water tanks. The sensors to measure water level are placed inside water tanks, which then report the result to the users. Ulumuddin, et al and Shankar et al use sensors to monitor water levels and a local web server to store and display the data on a web page. Both systems did not use any automation process, meaning a user needed to turn the pump on or off manually. Meanwhile, Irvawansyah et al added an automatic mode to their system which turns the water pump on or off when the water reaches a certain level using additional relay modules. If the automatic mode should fail due to certain circumstances, the user can disable the automatic mode and use the manual mode instead. All the systems mentioned above require users to be in the same location as the server because the web page and the desktop application can only be accessed locally using intranet.

Samsugi et al [4] and Abidin [9] created a system to automatically open and close floodgates using ultrasonic sensors to measure the water level. The results are then reported to the control center which is Arduino Uno. The control center will determine to open or close the floodgate. Samsugi system is used in rice fields' irrigation gates. Meanwhile, Abidin system is used in water reservoirs or dams and can be monitored on a web page. The system can be accessed publicly because it is connected to the internet.

Ilmah, et al [5], Samsugi, et al [4], Supriyade, et al [7], and Abidin [9] created water level monitoring system for outdoor used, which are fish ponds, rice fields, rivers, and reservoir floodgate, respectively. The sensors to measure water levels must be placed in certain places to get the correct result. The results can be various depending on the place where it is used. Similar to Supriyade, Chamim et al [12] created the same system for different purposes: early warning. The system reports the water level to a web server and displays it to authority as real-time charts. The following action when water reaches certain level is giving the status report, indicates by the color of the light in the website, which are blue, green, yellow, and red. The color represents the danger that may caused by the water level.

Previous research on observing water contents and conditions, such as salt concentration, temperature, or total dissolved solids (TDS) [11], are used in some places as well, such as fish ponds [11], and aquariums [13]. Water contents measured in those research are combined with water level parameters for more specific use. For example, sensors in fish ponds and aquariums are used to know if the water needs changing because bad water parameters can affect the fish’s life. In salt-making ponds, it is used whether to drain or add more saltwater until the salt concentration is needed to form the salt.

Ilmah et al [5] created a monitoring system that measures the water level. The system measures water levels and reports the results using SMS to the farmers. On the other hand, Ramadhana, et al [11] also measure temperature, PH, and TDS. Furthermore, the system reports the result to an Android device owned by the farmers. Both systems are applied in fish ponds. In fish ponds, more factors contribute to water quality for the fish. Suitable water parameters are needed for specific fish, like brackish water for milkfish [11].

The previous studies still have several areas for improvement, including there is no control by the user through the Android interface, some still use the intranet, which requires the user to be in the exact scene, and some are still limited by distance because they use Bluetooth technology. This study discusses the development of a prototype system monitoring and controlling salt ponds that can make it easier for farmers to remotely control the irrigation of reservoirs and plots by using Wemos D1 mini as a microcontroller, HC-SR04 sensor to measure water level, and salinity sensor to measure salt levels. The salinity sensor uses the Total Dissolved Solid (TDS) with the same principle as the conductivity where two electrodes are placed in a liquid. The fluid delivers electricity according to the ion concentration of the solution [14, 13]. Salinity is a level of a water-soluble salt. The salinity unit is a part per thousand (ppt) or represents its comparative water-dissolved salt [15, 16]. The innovation developed is that irrigation control for reservoirs and plots can be done automatically or manually through the Android application.

2. Research Method

The prototyping method, a software development method in which the physical working model of a system or subsystem serves as an initial version of the system or component, is used in this research. The method has the following stages: requirements gathering and analysis, quick design, prototype building, and user evaluation. The result of the user evaluation step will be used to refine the prototype [17].

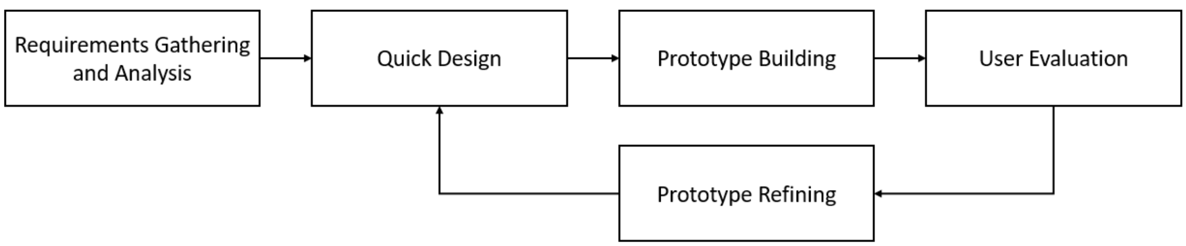

Figure 1. Method Prototyping according to Ogedebe

2.1. Requirements Gathering and Analysis

At the initial stage, the author as a system developer conducts a literature study to find information about previous technologies through several journals, articles, and websites regarding the outline of the system [17]. Monitoring and Salt Pond Controlling. Observations were made at the pond in Tlogoharum village, Pati. At this stage, much information is obtained about making salt ponds. Researchers also got information about system development in ponds from salt farmers to adjust the tools and systems for Monitoring and Controlling Salt Ponds to the real conditions in the field.

2.2. Quick Design

This quick design was created using Fritzing software as a hardware circuit design. The design of application wireframes, flowcharts, and deployment diagrams was made using Whimsical software, and the 3D design of the building frame was made using Solidworks software to adjust the specifications for the size of the pond and the tools to be built.

2.3. Build a Prototype

Making a system is the stage of making tools, assembling hardware based on a quick design made using fritzing software. Then an Android application was also created.

2.4. User Evaluation and Refining Prototype
This stage is an activity to test the feasibility of tools and applications. This test is carried out by the black-blox testing method. The use of the black-box testing method was chosen to ensure whether the features of the application run normally and smoothly. Then after the system is tested, the next step is repair. Repairs are immediately carried out if the test results do not meet the objectives.

3. Results and Discussion

3.1. Design Results
This application uses the platform android application. The database used in this system is Firebase Realtime Databases. The system must be connected to the internet to interact with the database.

3.2. Diagram Block
Diagram block are used to find out how the Salt Pond Monitoring and Controlling system is in the form of block diagrams as shown in Figure 3.2. Figure 3.2 can be seen that Wemos D1 on monitoring, will be connected to the salinity sensor, HC-SR04 and LCD I2C. While the second Wemos on the controlling will be connected to a 2-channel relay and two mini dc celum pumps. Both wemos D1 mini microcontrollers will be connected to firebase and internet network to send and receive data. The application will access the firebase to retrieve its data and display it in the SiTaGar android application.

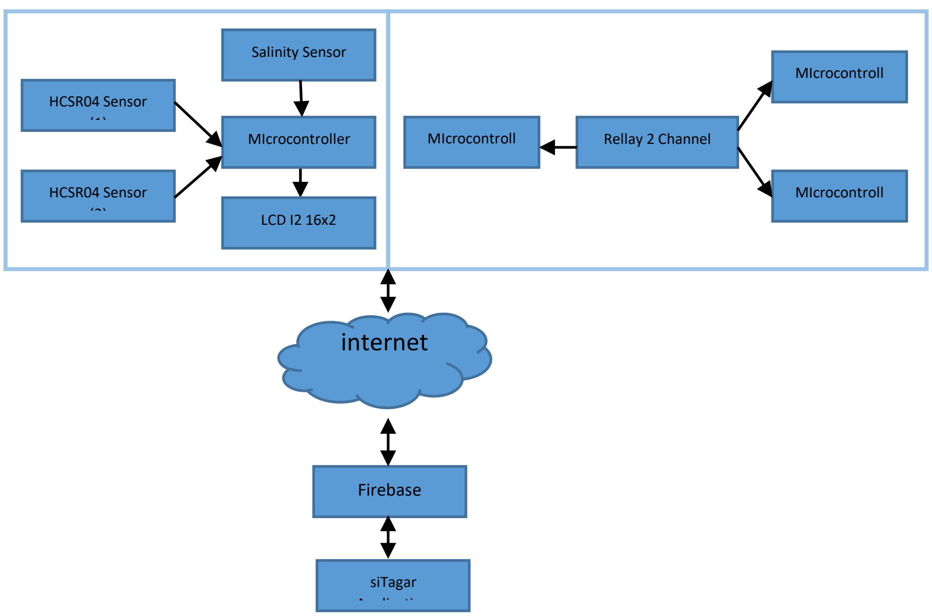

Figure 2. System Diagram Block

3.3. Hardware Requirements
The hardware needed to build a system This application uses the platform android application. The database used in this system is Firebase Realtime Databases. To interact with the database the system must be connected to the internet.

1. Wemos D1 Mini
2. Relay Module 2 Channel
3. Adapter Power Supply
4. Electrical Capacitor

5. Jumper Cable
6. Salinity sensor
7. Ultrasonic Sensor
8. Water Pump Mini
9. LCD I2C 16x2

3.4. Software Requirements

The software needed to build a Salt Pond Monitoring and Controlling System is as follows:

1. Android Studio IDE
2. Arduino IDE
3. Google Chrome
4. Firebase Realtime Database
5. Whimsical

3.5. Functionality

3.5.1. Test Results Tool Functionality Test Results

The tools in this system are two plastic containers. The first container measuring 21 cm x 15 cm x 14 cm is used as a shelter above it there is an HC-SR04 sensor then the second container measuring 21 cm x 15 cm x 10 cm is used as a plot in which there is a salinity sensor and on top there is an HC-SR04 sensor. Both containers are placed on a board measuring 40 cm x 45 cm.

Figure 3. Prototype of the tools

The results of testing the water level in the reservoir and plot using the ultrasonic sensor or HC-SR04 which is above the reservoir can measure the distance from the sensor to the object in front of it, namely the sensor will detect increasing or decreasing water.

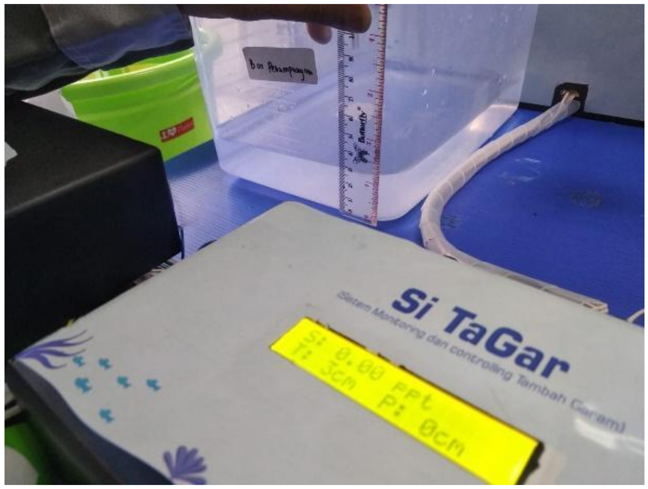

Figure 4. Testing the height of the water reservoir

The result of the salinity sensor test is that it can measure the salinity value of the water in the plot. Testing the salinity sensor using a refractometer. Generally, the salinity conditions in the last plot of the salt pond are around 19-25ppt. The test results can be seen in Table 1. The value standard for the error obtained from testing the salinity sensor on the plot is 0.72.

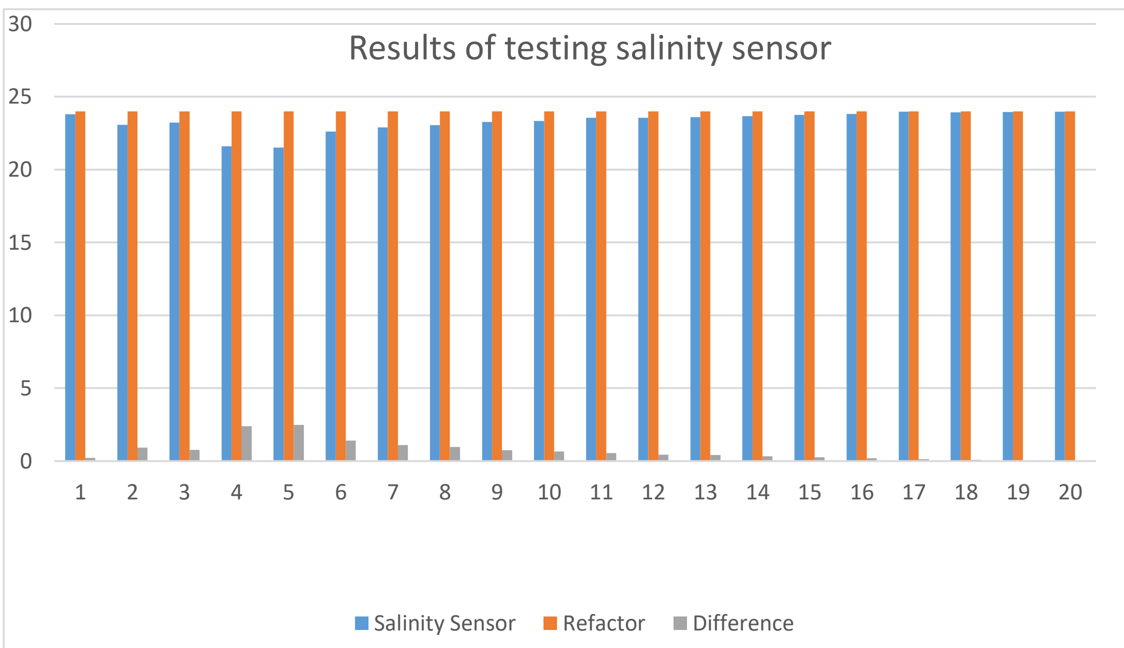

Figure 5. Results of testing salinity sensor

3.5.2. Application Functionality Test Results

In testing the functionality of this application, a trial was conducted on each feature of the Sitagar application using 3 smartphones with different operating systems. All features have successfully been tested and run well on each smartphone. There are 3 features in the SiTaGar application, namely the Home menu, Weather, and Info. To enter the system, the user needs to enter a PIN verified by the system as shown in Figure 4. The user will enter the home menu if the pin has been registered.

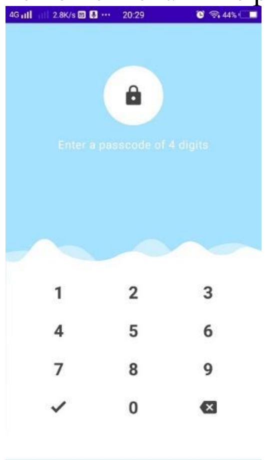

Figure 6. Display of the log in

The home menu in Figure 5 contains monitoring, both monitoring the height of the reservoir water, plot water, and salinity. In addition, this menu can be used to control the pump, either manually or automatically.

Figure 7. Home menu

When the water pump is switched on manually using a button on the android, then the 1 relay on the device will turn red, and the pump will drain the water. This can be seen in Figure 7.

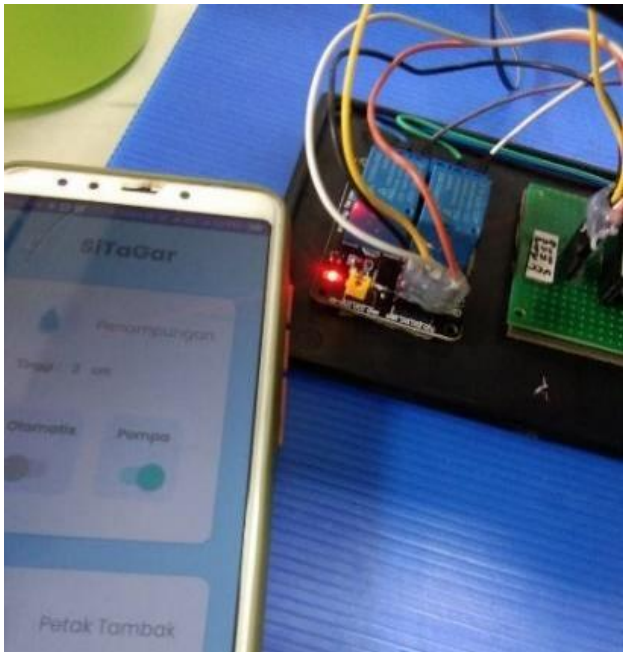

Figure 8. Pump on

The Weather page contains information about the current weather and hourly weather forecasts in 1x24 hours. This weather forecast is taken from the API OpenWeather according to the provider's location as shown in Figure 7.

Figure 8. Weather menu

There is the info menu, such as its name it serves to give the user information on how to use the tools and applications or can also be called the manual book, which can be seen in Figure 8.

Figure 9. Info menu

When the info menu selects a guide option using the sitso application, it will show the use of the sitadate application, as seen in Figure 10.

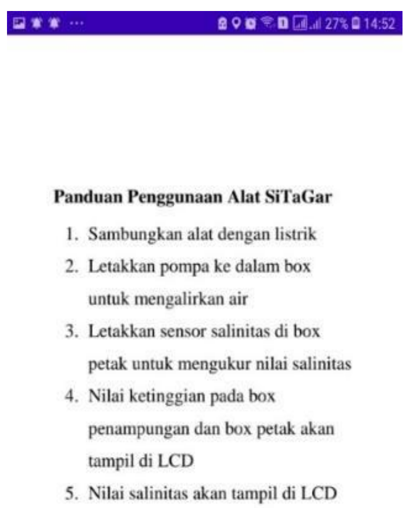

Figure 10. Manual book sitagar

Based on the trial implementation of applications on Android OS versions experimental results are summarized in Table 1.

Table 1. Results of implementation and application in android

Operating System Android	Specification
Android 5 Lollipops	Successfully
Android 7.1..2 Nuggat	Successfully
Android 8.1 Oreo	Successfully

3.6. User Satisfaction

The testing of the Salt Pond Monitoring and Controlling System tool uses several questions to get the calculation results that are used as a reference to determine the level of user satisfaction in its use. Calculating the level of user satisfaction is obtained by comparing the total user satisfaction with its use. The list of questions can be seen in Table 2

Table 2. User Satisfaction Question Criteria

No.	Question Criteria
1.	How useful is the function of the Salt Farm Monitoring and Controlling System?
2.	How useful is the function of the Salt Pond Monitoring and Controlling Application as an interface for the Salt Pond Monitoring and Controlling System?
3.	How easy is it to monitor water levels in reservoirs and plots and salinity values in salt ponds?
4.	How easy is it to use the SiTaGar Application?
5.	How successful is the automatic pump feature in the Salt Pond Monitoring and Controlling System?
6.	How successful is manual pump control?
8.	How successful is the remote salt pond monitoring and controlling system application?
9.	How is the actual water level in the reservoir?
10.	How actual is the salinity value?

This test was conducted in the village of Tlogoharum Pati. At this stage, a system testing process has been completed and tested to real users, namely salt pond farmers. The following are questions asked to 10 different respondents.

Table 3. User Satisfaction Results

No	Name	A list of questions										Total value
		1	2	3	4	5	6	7	8	9	10	
1	Moh. Ismail	5	4	5	5	5	5	5	4	4	3	45
2	Sukir	4	5	5	4	5	4	4	5	4	4	44
3	Kasupi	5	4	5	5	4	5	4	5	5	4	46
4	Ali Marsudi	5	4	4	4	5	4	4	5	5	4	44
5	Sukimin	5	4	5	5	4	5	5	4	4	3	44
6	Dani	5	4	5	5	5	5	5	5	4	5	48
7	Boman	4	5	5	5	5	5	5	4	4	4	46
8	Fina Lutfiana	4	5	4	4	5	4	4	5	5	5	45

9	M. Gunawan	4	5	4	3	4	4	4	5	4	4	41
10	Suntani	4	4	5	5	5	5	5	5	4	4	46
				Total								449

Table 4. Questionnaire assessment guide

Predicate	Value
Very Satisfied	5
Satisfied	4
Fairly Satisfied	3
Dissatisfied	2
Very Dissatisfied	1

Tabel 5. User satisfaction indicator

Value	Description
80-100%	Very Satisfied
60-80%	Satisfied
40-60%	Fairly Satisfied
20-40%	Dissatisfied
0-20%	Very Dissatisfied

The following are the results of respondents' assessments regarding the System Design Monitoring and Controlling Salt Ponds from 10 respondents, as shown in Table 4.

$$\text{Total maximum satisfaction score 50 (user indicator) x 10 (user)} = 500 \tag{1}$$

Percentage of User Satisfaction (%):

$$\frac{\text{Total user satisfaction}}{\text{Total Maximum User Satisfaction}} \text{x } 100\% = \frac{449}{500} \text{x } 100\% = 89.8\% \tag{2}$$

Based on the test results the level of satisfaction to salt farmers can be obtained at 89.8%. The percentage is calculated using the formula for comparing total user satisfaction to maximum user satisfaction, so it can be concluded that the Design and Construction of the System is Monitoring and Controlling Salt Ponds very satisfactory. This study has features in common with several previous studies, namely the water level monitoring feature [4, 5, 6, 7, 8], salt level monitoring features [11], and irrigation control features [4, 8, 9]. This system has combined some of these features and added manual and automatic pump control innovation through the Android application. In addition, this system has a water level monitoring feature in the reservoir and plot basins and the salinity value.

4. Conclusion

Based on the results of this research, the following conclusions can be drawn:

- The feature monitoring water level in the reservoir and plot basins and the salinity value has been functioning correctly.
- The pump control features in the reservoir and pool tanks can work correctly.
- Automatic and manual pump features can work correctly.
- The sensor on the device sends data to the Firebase database which in real time appears in the Android application on the smartphone
- The results of the salinity sensor test show a standard error of 0.72.
- The results of the HC-SR04 Sensor test for the average water level of the plots and reservoirs have a standard error of 0.4.

The results of the questionnaire test from 10 respondents of pond farmers obtained a satisfaction level of 89.8% which means that salt pond farmers are very satisfied with the design and construction of the system monitoring and controlling salt pond.

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