Assessment of Technology Acceptance Model of Water Quality Monitoring Technology Application on Rural Areas of Jember Regency

Bagus Setya Rintyarna[1], Rusdiana Setyaningtyas[2], Daryanto[3], Ika Safitri Windiarti[4]

[1,2,3]*Universitas Muhammadiyah Jember*
[4]*Universitas Muhammadiyah Palangkaraya*

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Abstract - **Both the Indonesia Constitution and the SDGs have mandated the provision of clean water for the citizens. In the implementation, central government established centralized water supply system (CWSS) managed by regional drinking water company domiciled in the district region, namely Perusahaan Daerah Air Minum (PDAM). Unfortunately, access to the services of CWSS facility is overall very limited due to the limited water infrastructure of PDAM. Commonly, the services only reach urban areas near the district capital. In response to the limited access of CWSS facility, an independent community based clean water provision called decentralized water supply system (DWSS) is proliferatedly developed in Indonesia. The central government, realizing the limited access to CWSS facility especially in rural areas, support DWSS by providing water treatment plant. Another facility is independently prepared by the community. An important problem faced by DWSS managers is the guarantee of water quality standards. This work aims at: 1) designing a water quality monitoring technology based on Arduino Uno and an Ensemble Classifier, 2) assess the acceptance of the DWSS community in the application of the technology. The result of TAM evaluation will be beneficial in terms of: 1) adapting the technology design/characteristics with the user's need and, 2) extending the application of the technology to the other areas of Jember regency.**

INTRODUCTION

In Indonesia, provision of clean water is a mandate of the constitution [1]. Moreover, access to safe and decent drinking water is also one of the Sustainable Development Goals (SDGs) target as established by the United Nation to be the world agenda since 2015 [2]. Hence, the central government of Indonesea has outlined the credential into National Mid-Term Development Plan (RPJMN) 2020 to 2024. The provision of clean water supply, as a follow up, is then handed over to regional drinking water company domiciled in the district region, namely Perusahaan Daerah Air Minum (PDAM). In term of Indonesia clean water provision system, PDAM is called centralized water supply system (CWSS) [3].

CWSS provides completed piped water suppy consisting ground water supply, water treatment plant and distribution network established by the Indonesian government as the authority to supply drinking water [4].

Unfortunately, access to the services of CWSS facility is overall very limited in many regions of Indonesia including in Jember regency which is located in eastern part of Jawa Timur Province. Bordering Bondowoso, Lumajang and Banyuwangi regencies, administratively Jember has 31 sub-districts with 226 villages. Of the 31 sub-districts in Jember regency, only 9 sub-districts that have access to drinking water provided by PDAM Jember. These sub-districts are urban sub-districts located near the capital city of Jember Regency [4]. Sub-districts located in the rural areas of Jember regency is commonly still out of service. The main problem headed by PDAM Jember to extent the area of services is the limited of funding to equipt more water infrastructure. The focus of clean water service is hence still limited in urban areas.

In response to the limited access of CWSS facility, an independent community based clean water provision is proliferatedly developed in Indonesia. This community based system is called decentralized water supply system (DWSS) [5]. Commonly, DWSS is independently managed and operated by a village owned enterprises called Badan Usaha Milik Desa (BUMDES). Realizing the lack of access to CWSS facilities, the government encourages the development of DWSS through a national program called PAMSIMAS, a community-based water supply system. Trough PAMSIMAS, central government provide financial support for village DWSS manager to build simple water treatment plant. For Jember regency, PAMSIMAS has succesfully support the development of water treatment plants in 223 villages. The main issue headed by DWSS manager with this simple water treatment plant is the continuous monitoring of the water quality produced by the plant.

The provisions stipulated in Permenkes No. 32 of 2017 concerning environmental health quality standards and water health requirements explains that water consumed by the community must meet quality standards [3].

According to previously described gap, this work attempts at supporting DWSS manager by providing a system embedded to the simple water treatment plant that is able to continuously monitor and record [6] the water quality produced by the plant. This system ensures that the water distributed to customers meets water quality standards [7]. Otherwise, the water needs to be processed further or its distribution is temporarily halted to ensure the health of the customers [8]. In designing the water quality monitoring technology, we use Arduino Uno as the central processing unit and an ensemble classifier as the algorithm to classify water quality. The framework of the technology will further be described in Section Method.

We also aim at assessing customer acceptance to the application of water quality monitoring technology using a Technology Acceptance Model (TAM) metrics. TAM is able to mediate the property of the system with usage behavior of user [7]. As the sample, we studied costumer from Lembengan village of Jember regency. The result of TAM evaluation will be beneficial in terms of: 1) adapting the technology design/characteristics with the user's need and, 2) extending the application of the technology to the other areas of Jember regency.
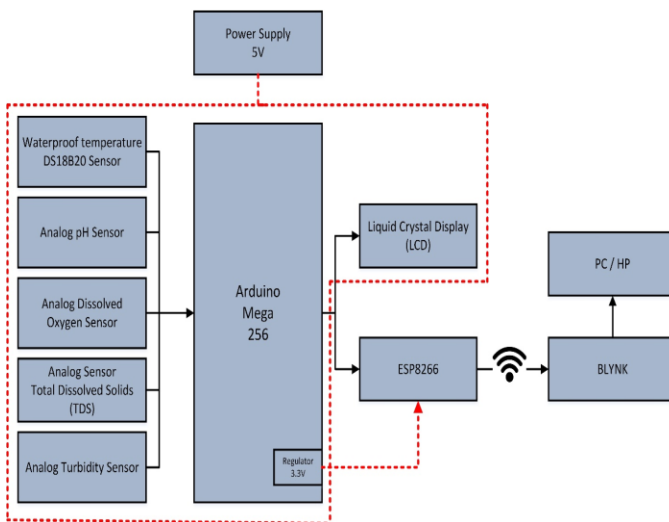

Fig. 1 Framework of the designed monitoring technology using Smart PLS 4.0

DESIGN OF WATER QUALITY MONITORING TECHNOLOGY

The framework of the proposed technology can be described in schematic diagram as presented in Fig. 1. The framework illustrates that there are three main parts of the system i.e.: input, process, and output section. Sensors consisting of DS18B20, PH, *Dissolved Oxygen* (DO), *Total Dissolved Solid* (TDS), dan Turbidity are embedded to input section. The DS18B20 is a digital temperature one wire communication sensor that has an internal 12-bit ADC. In a temperature range of -10 to +85 degrees Celsius, this sensor has an accuracy of +/-0.5 degrees. For PH sensor, we use Analog pH meter V2 from DFRobot Gravity.

The sensor measures hydrogen ion concentration index of the solution. Compared to its predecessor, the V1, pH meter V2 has better precission. Beside having low jitter of the output signal, it is also compatible for 5V and 3.3V main control board. For dissolved oxygen, we use DFRobot Analog Dissolved Oxygen Sensor Meter Kit for Arduino. The sensor measures the amount of oxygen dissolved in the water. Meanwhile, to measure total dissolved solids representing total concentration of dissolved substances in water, we use Gravity Analog TDS sensor from DFRobot. Level of turbidity indicating water quality is also detected by using Gravity Arduiono Turbidity sensors.

As a central processing unit in the designed water monitoring system, we use Arduino Mega 256. Arduino is an open-source electronic platform to work with an interactive environment for a large number of applications [9]. It is more popular compared with previous programmable circuit board as it is simple and easy to use consisting both microcontroller and integrated development environment (IDE) to write and upload script to physical board. Arduino Mega 256 is the latest version of Arduino with the biggest capacity of flash memory, SRAM, and EEPROM that make it more flexible in uploading more complicated script.

Arduino Mega 256 is used to read and process sensor's data. We also apply rule to determine the quality of water validated by using several ground truths. Arduino also plays a role in displaying the result into LCD and controlling ESP8266 i.e.: low-cost wireless microchip having a built-in TCP/IP networking protocols to communicate with 2.4 Ghz Wi-Fi. The role of Arduino in controlling the other devices can be illustrated by using flow chart in Fig.3. At last, the result of monitoring is then displayed in user's smartphone trough blink application as presented in Fig. 2.

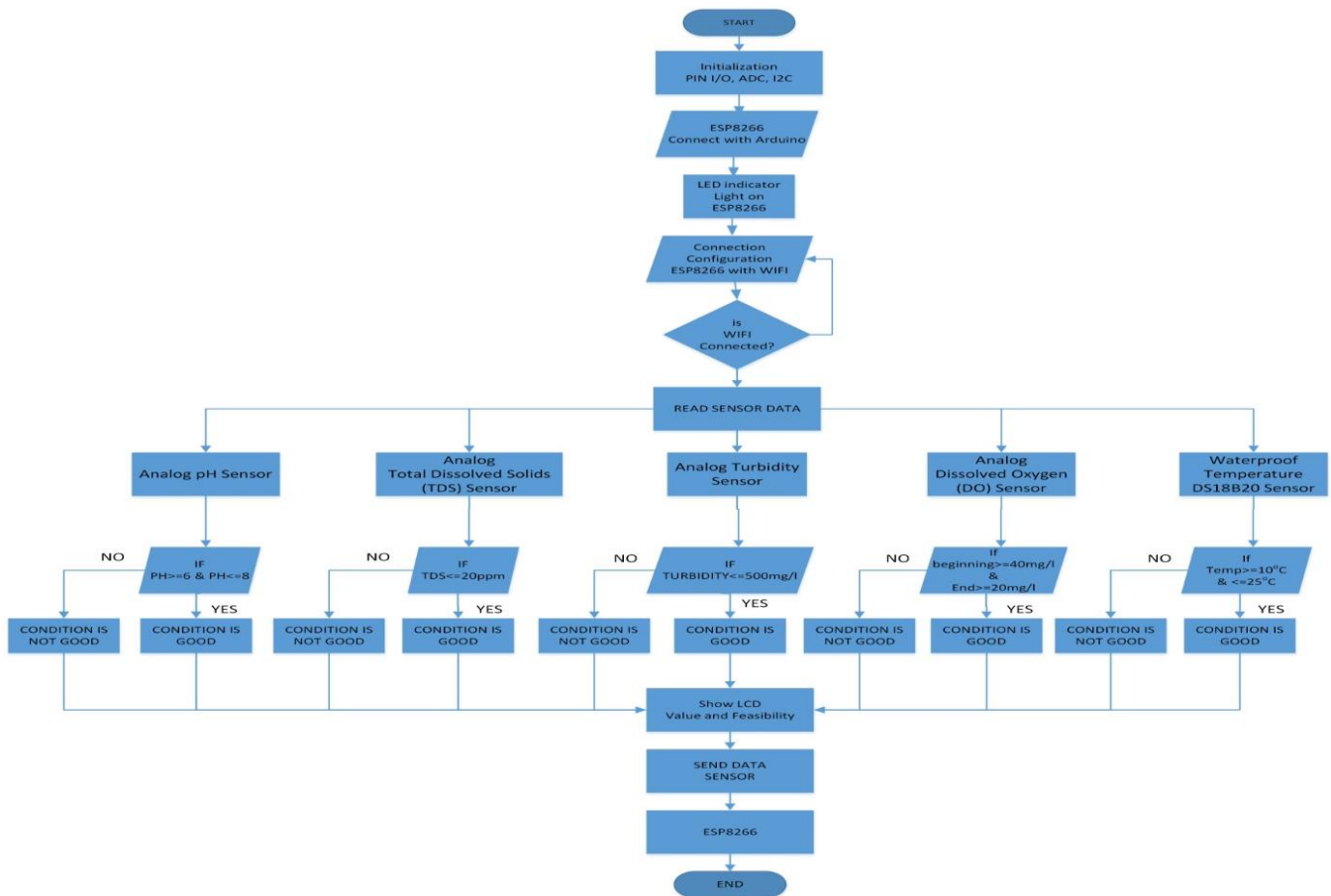**Fig 2. Screenshot of Blynk Application in Android**

Fig. 3 Flow chart of the systems using Smart PLS 4.0

ASSESSMENT OF USER'S ACCEPTANCE TOWARD WATER QUALITY MONITORING TECHNOLOGY

Literature and hyphotheses development

Based on theory of reasoned action (TRA) i.e.: theory that explains human behavior [10] especially aiming at understanding and perceiving how people approve and use technology [11], we apply technology acceptance model (TAM) to address the issue of how users can accept and use the designed water quality monitoring technology implemented in one of urban areas of Jember regency namely Lembengan. TAM is the most influential model concerning innovation acceptance [12].

In applying TAM, we apply 4 variables namely perceived ease of use (PEU) and perceived usefulness (PU). Both variables influence actual usage (AU) trough attitude (A). Conceptual framework depicting relationship between variables is presented in Fig 4.
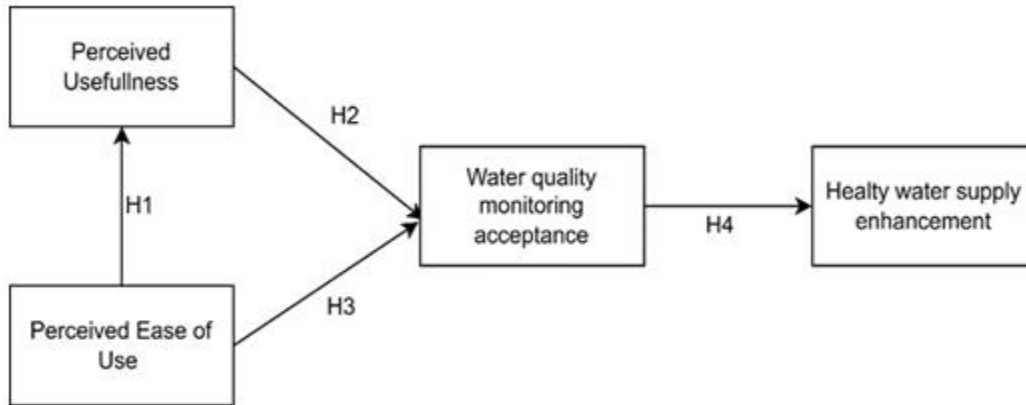

Fig 4. Conceptual Framework of TAM based on applied in this work using Smart PLS 4.0

The aim of this study is to investigate how the acceptance toward the implementation of water quality monitoring technology would, in turn, affect positively to healty water supply enhancement trough assesing the perception of people toward ease of use and usefulness of the water quality monitoring technology.

Perceived ease of use portrays the degree to which user comprehend the applied technology to be free from effort [13]. In this work, we would like to asses how perceived ease of water quality monitoring technology use influence its perceived usefullness. As stated by [14], perceived ease of use positively affect perceived usefullness in self-service technology. To add, [15] has also confirmed the positive effect of both perceive of use and perceived usefullness to the intention of applying E-Government in Malaysia. Based on the literature study and the presented conceptual framework, we then derrive 4 hypothesis concerning with the application of water quality monitoring technology in Jember especially in Lembengan village. The hyphothesis is decribed as follows:

H1: Perceived ease of using water quality monitoring technology positively influences perceived usefullness of the technology

H2: Perceived usefulness positively influences the acceptance toward the implementation of water quality monitoring technology

H3: Perceived ease of use positively influences the acceptance toward the implementation of water quality monitoring technology

H4: The acceptance toward the implementation of water quality monitoring technology positively influences healty water supply enhancement.

INSTRUMENTS

Adopting TAM [16], we design questionnaire comprising 4 sections representing four pre defined variables i.e.: 1) perceived ease of use, 2) perceived usefulness, 3) water quality monitoring acceptance and 4) healty water supply enhancement. The derived indicator of every section is presented in Table 1.

Table 1
Indicator of the variables

Variable	Indicators
Perceived ease of use	1. I can use water quality monitoring application easily 2. I do not spend much time to learn to use the app 3. It is easy for me to remember how to perform features of water quality monitoring application
Perceived usefulness	1. Water quality monitoring application provides accurate information dealing with water quality in SPAM installations 2. The continuous monitoring application provides the necessary information for the community
Attitude towar using the application	1. I intend to continue using the water quality monitoring application to get accurate information about water quality at the SPAM installation
	2. The water quality monitoring application plays an important role in improving the quality of public health through the provision of safe water for consumption
Public acceptance toward water quality monitoring technology	1. I accept the continuous monitoring application as a useful application in providing accurate information about water quality in SPAM installations 2. I will also invite others to use the continuous monitoring application to monitor water quality in SPAM installations

To evaluate our hypothesis, we conduct Partial Least Square analyis using Smart PLS 4.0. The experimented model can be described in Fig. 5 as follows:
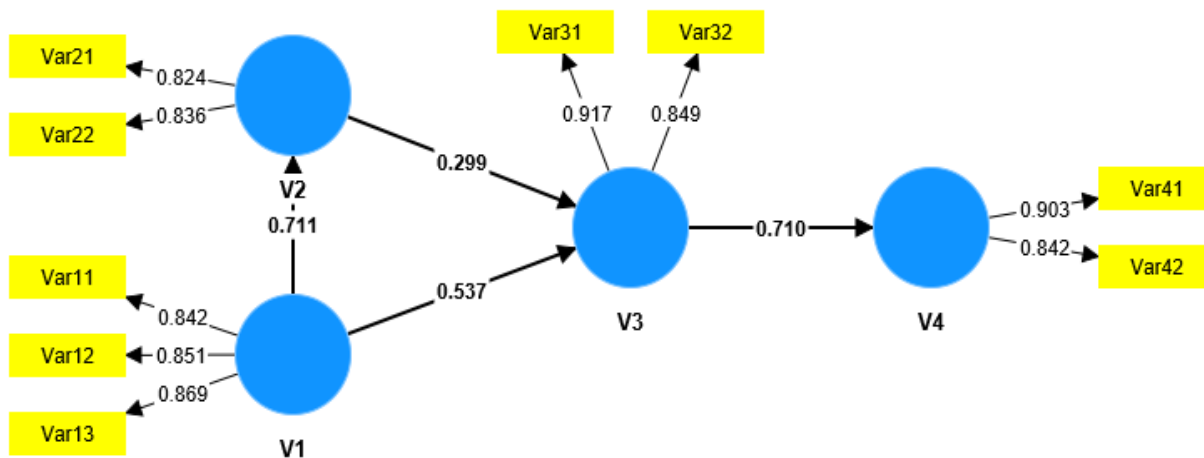

Fig 5. Outer model construct of Partial Least Square using Smart PLS 4.0

To evaluate convergent validity between indicators and their latent variabel, we measure outer loading as presented in Table 3. To assess convergent validity, we calculate loading factor. The result of the calculation is presented in Table 2. Outer loadings are tables containing loading factors to show the correlation between indicators and latent variables. An indicator is declared to meet convergent validity in the good category if the outer loading value is > 0.7. Yet, according to Chin, outer loading value between 0.5 to 0.6 is sufficient to fulfill convergent validity. From Table 3, we can conclude that all indicators are declared feasible or valid for research use and can be used for further analysis. Meanwhile, the result of path coefficient is presented in Fig. 6. Path coefficients important to indicate the direction of the relationship to the variable, whether a hypothesis has a positive or negative direction.

Table 2.
Outer loading

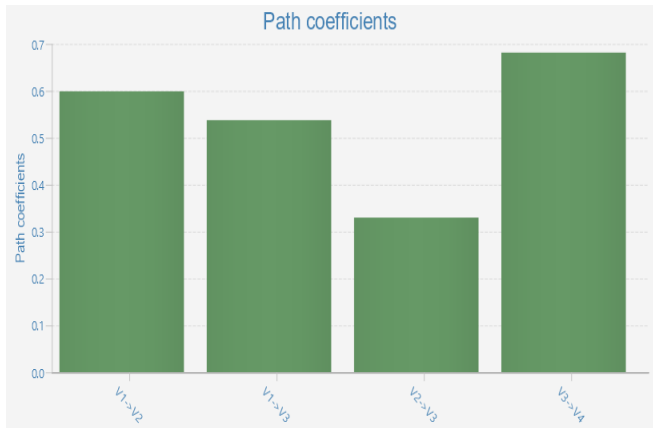|	Outer loadings
Var11 <- V1	0.756
Var12 <- V1	0.842
Var13 <- V1	0.879
Var21 <- V2	0.659
Var22 <- V2	0.854
Var31 <- V3	0.918
Var32 <- V3	0.848
Var41 <- V4	0.884
Var42 <- V4	0.842

Fig 6. Path Coefficient

We also evaluate cross loading, indicating discriminant validity. An indicator is declared to meet discriminant validity if the indicator's cross loading value on the variable is the largest compared to other variables. The result of cross loading calculation is presented in Table 2. Table 2 shows that all indicator has proper discriminant validity.

Table 2.
Cross loading

	V1	V2	V3	V4
Var11	0.756	0.440	0.470	0.479
Var12	0.842	0.508	0.719	0.578
Var13	0.879	0.534	0.606	0.522
Var21	0.285	0.659	0.475	0.476
Var22	0.588	0.854	0.526	0.405
Var31	0.695	0.640	0.918	0.711
Var32	0.596	0.498	0.848	0.465
Var41	0.636	0.584	0.628	0.884
Var42	0.455	0.369	0.544	0.842

CONCLUSION

Both the Indonesia Constitution and the SDGs have mandated the provision of clean water for the citizens. In the implementation, central government established centralized water supply system (CWSS) managed by regional drinking water company domiciled in the district region, namely Perusahaan Daerah Air Minum (PDAM). Unfortunately, access to the services of CWSS facility is overall very limited due to the limited water infrastructure of PDAM. Commonly, the services only reach urban areas near the district capital. In response to the limited access of CWSS facility, an independent community based clean water provision called decentralized water supply system (DWSS) is proliferatedly developed in Indonesia. The central government, realizing the limited access to CWSS facility especially in rural areas, support DWSS by providing water treatment plant. Another facility is independently prepared by the community. An important problem faced by DWSS managers is the guarantee of water quality standards.

This work aims at: 1) designing a water quality monitoring technology based on Arduino Uno and an Ensemble Classifier, 2) assess the acceptance of the DWSS community in the application of the technology. The result of TAM evaluation will be beneficial in terms of: 1) adapting the technology design/characteristics with the user's need and, 2) extending the application of the technology to the other areas of Jember regency. Evaluation conducted using PLS SEM support the intial hypothesis.

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AUTHOR INFORMATION

Bagus Setya Rintyarna, Assistant Professor, Department of Electrical Engineering, Universitas Muhammadiyah Jember

Rusdiana Setyaningtyas, Lecturer, Department of Civil Engineering, Universitas Muhammadiyah Jember

Daryanto, Lecturer, Department of Informatics, Universitas Muhammadiyah Jember

Ika Safitri Windiarti, Associate Professor, Department of Computer Science, Universitas Muhammadiyah Palangkaraya