

Sluice Gates Digitalization of Serinjing Main Canal in Siman Irrigation Area Jombang District

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ABSTRACT

Indonesia agricultural sector relies heavily on efficient irrigation systems to support food security, yet most existing irrigation systems still rely on manual methods, which can lead to unequal water distribution and operational inefficiencies. This research aims to analyze the application of sluice gates digitalization as a solution to improve water management efficiency of Serinjing Main Canal in Siman Irrigation Area, East Java. Siman Irrigation Area covers an area of 23,060 hectares spread across Jombang, Kediri and Malang Regencies where the sluice gates in this area still manually operated. Sluice gate digitalization is the process of modernizing sluice gate by using automation technology and real-time monitoring. Sluice gate digitization can improve supervision and control of water distribution, leading to more transparent and coordinated management. This research involves the creation of a smart irrigation system application, sluice gate automation, application of information technology for smart programming and early warning systems. Digitalization of sluice gates is expected to resolve various problems arising from manual management, such as unequal water distribution, misappropriation of water distribution, and lack of coordination between officers. This research concludes that digitalization of sluice gates can improve the efficiency of irrigation systems, support agricultural sustainability, and make a positive contribution to national food security.

Keywords: Digitalization, Irrigation, Real-Time, Sluice Gate.

INTRODUCTION

Irrigation water needs is one of the most important aspects on the agricultural sector in Indonesia (Sandi & Fatma, 2023). Indonesian population growth has an impact on the fulfillment of food needs, so an efficient and modern irrigation system is one of the main focuses of the government. According to (Priyonugroho, 2014), irrigation water in Indonesia is mostly sourced from rivers, reservoirs, groundwater, and tidal systems (Patriadi et al., 2024). Each of these sources has challenges in management and distribution, especially if it still use manual methods.

The predominance of manual systems in the management of irrigation systems often leads to optimization, especially during the dry season. Dependence on erratic rainfall increases the risk of crop failure, which makes irrigation an important instrument for sustaining agricultural

output (Mack et al., 2020). Research shows that regular water availability through irrigation systems not only increases crop yields but also has a direct impact on increasing farmers' income, especially in the dry season (Purwantini & Suhaeti, 2017). One of the solution that can be applied to overcome this problem is the digitalization of irrigation systems. Digitalization allows real-time management and monitoring of water distribution, so that transparency and accuracy of water distribution can be improved. With this technology, dependence on manual systems that are less adaptive to changes in water demand can be reduced.

The government through the Ministry of Public Works and Public Housing has initiated a sluice digitalization program to support food sovereignty (Noor & Sulaeman, 2022). The program is designed to improve the efficiency of irrigation management by utilizing automation technology on sluice gates. The Directorate General of Water Resources is tasked with overseeing the implementation of this program, which is planned to be implemented in several priority irrigation areas, one of which is the Siman Irrigation Area in East Java Province.

Siman Irrigation Area covers an area of 23,060 hectares spread across Jombang, Kediri and Malang Regencies. This area has irrigation infrastructure that includes reservoirs, main weirs, and hundreds of regulating and supplementary buildings. However, sluice gates in primary and secondary canal are still operated manually. This condition has an impact on the optimization of water distribution. On the dry season, the distribution of water was not optimal, especially on the downstream, resulting several violations in the form of illegal withdrawals directly from nearby canal to fulfill irrigation water needs. In addition, operation and maintenance officers from upstream to downstream have not been well coordinated and integrated.

Previous relevant research by (Samsugi et al., 2020) on Automatic Irrigation Control System using Arduino Uno Microcontroller regarding a system that can be an alternative to control water levels. The research is relevant to this research which has the conclusion that using an automatic irrigation controller system can make it easier for farmers to control the entry of water in the irrigation flow. In addition, other research was conducted by (Abraham et al., 2024), namely the Prototype Monitoring System for Water Levels and Water Flow Speeds at Internet of Things-Based Dams which aims to utilize the internet in various fields more deeply and widely. The system in the research was made in the form of a prototype, where the working system of the tool was able to monitor the height and flow of water velocity in the dam. After that, information on the status of the water level will be displayed on the website in real-time which can be monitored via an android smartphone.

Based on references from previous research, this research describes the application of sluice digitalization in Siman Irrigation Area. The application of sluice gates digitalization in Siman Irrigation Area is carried out through the development of an automatic system in the dividing building, tapping, and dividing tapping in the primary channel is expected to be a strategic step to overcome the existing problems. With this technology, water distribution expected to be more efficient, transparent, integrated, and able to support the sustainability of irrigation systems in

The type of research used in this research is qualitative research, qualitative research is a research that aims to describe and analyze phenomena, events, social activities, attitudes, beliefs, perceptions, thoughts of people individually or in groups. The purpose of using this research is to describe existing phenomena, both natural and human engineering, which pay more attention to the characteristics, quality, interrelationships between activities.

Problem Limitations

This research has several limitations to the problem set to clarify the scope of the research. First, the main focus of this research is on the process of digitizing the floodgates in the Siman Irrigation Area. This research specifically discusses the stages of implementing digitization, without discussing the results or impacts obtained after digitization is implemented.

Furthermore, the scope of the research is limited to the implementation of a sluice gate digitization system, including elements such as dividers, taps, and dividers on primary channels. Other technological aspects, such as digitization of secondary channels or additional infrastructure, are not discussed in detail in this research.

In addition, this research does not include a comparison of irrigation efficiency levels before and after digitization. The focus of the research is only on the development and implementation of a sluice gate automation system as a solution to water distribution problems, without including a discussion of the final results of the implemented system..

RESULT AND DISCUSSION

Sluice Gates Digitalization

Digitalization of sluice gates is one of Indonesia Government program to improve national food security. Digitalization is shown with the intention of monitoring the availability, needs, and distribution of water in real-time and transparently. In addition, the digitization of sluice gates also aims to help sluice gate officers to control sluice gates remotely. Therefore, this research will discuss the application of sluice digitalization in the research area.

Although irrigation system has an important role in supporting food security, the operation of sluice gates in the Siman Irrigation Area is still manually operated. This often leads to unequal water distribution, especially during the dry season, when downstream areas often experience water shortages (Anwar, 2017). This condition triggers complaints from farmers who feel that water distribution is unfair, so some of them are forced to take water illegally from nearby channels or even break the embankment to irrigate their land. In addition, the lack of coordination and integration between maintenance operation officers from upstream to downstream compounded water distribution problem.

The application of sluice gates digitalization in the Siman Irrigation Area is expected to be a solution to this problem. With a digital system, officers can monitor and control the floodgates in real-time directly from BBWS Brantas Surabaya Office and UPI DI Siman Jombang office. This technology not only simplifies the officers work, but also allows for more effective and

transparent supervision, so that water distribution becomes more equal and potential violations can be minimized.

Digitalization of the operation of the sluice gates in the Siman Irrigation Area is a series of activities aimed at automating the sluice gates. This activity includes door repair, actuator installation, Operation System Hydromechanical Internet (OPSHI) installation, Automatic Water Level Recorder (AWLR) installation and monitoring cameras (CCTV) on the floodgates in the Siman Irrigation Area where the officers can be operated remotely through the command center at the BBWS BRANTAS Surabaya Office and UPI DI Siman Jombang Office. The following will show the details of the sluice automation designed by the researcher.

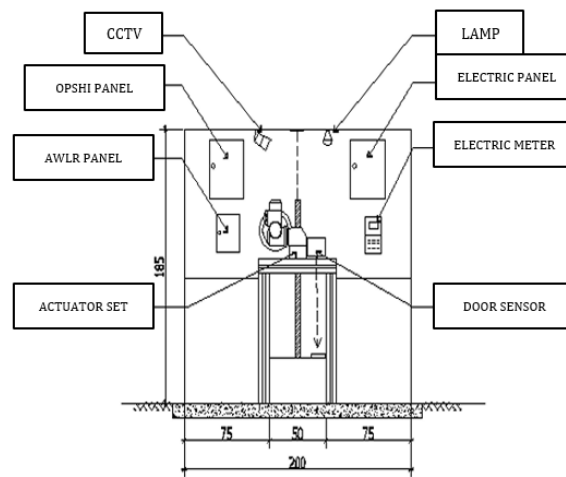


Figure 2. Detailed Door Automation

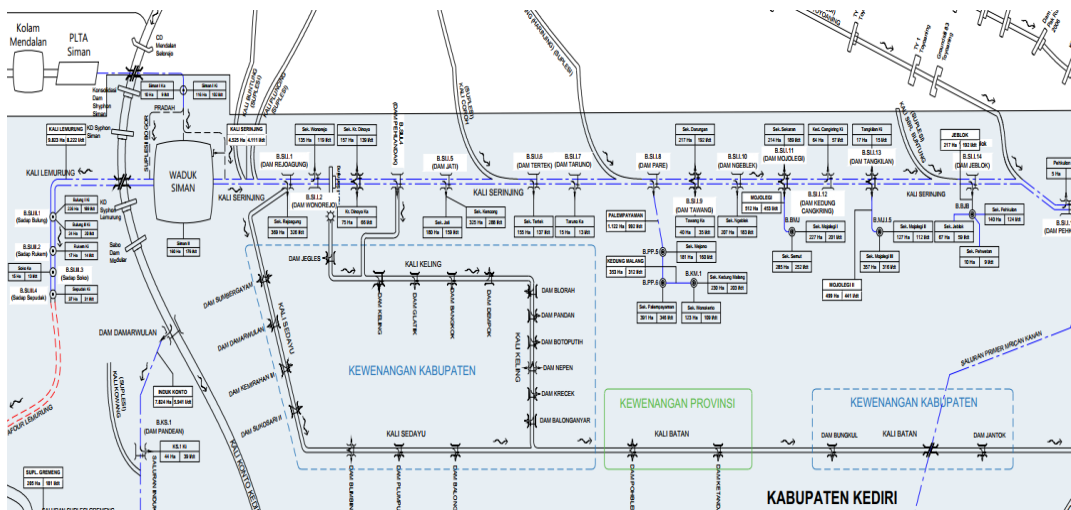


Figure 3. Schematic of Serinjing Primary Channel Digitalization

Implementation of Sluice Gates Digitalization on Siman Irrigation Area Real-Time Monitoring of Water Allocation in Irrigation Canals

The installation of Automatic Water Level Recorder (AWLR) includes the installation of Luwes Water Sensor Promithevo Online Water Level Sensor (Lite) and Luwes Water Sensor

Peilshcaal (Parwita, 2017). Automatic Water Level Recorder (AWLR) used to measure the water level connected to the dashboard in the command center of the BBWS Brantas Surabaya Office and the UPI DI Siman Jombang Office so that it can be controlled remotely to transmit data in real time.

Smart Irrigation System Application Development

Installation of Operation System Hydromechanical Internet (OPSHI) is a dashboard application, sluice control systems integration, water level integration, CCTV integration, and irrigation schemes integration (Mindiaستیwi & Pranida, 2023) that directly connected to the command center of BBWS Brantas Surabaya Office and UPI DI Siman Jombang Office. This installation allows officer to transmit data remotely in real time.

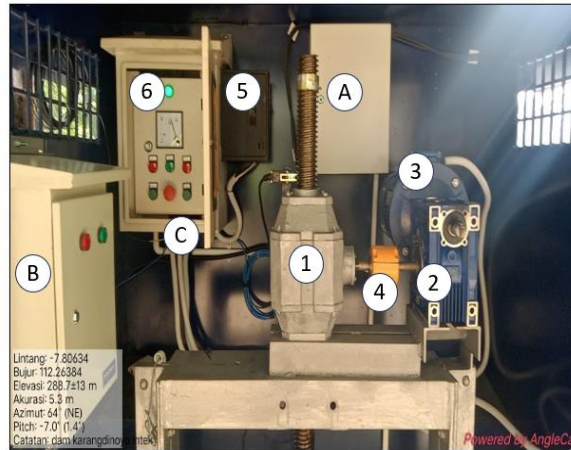
Door Automation Work

There are several tools in door automation work to replaced and installed, as follows:

1. Water Gate Modification and Rehabilitation Works: 286 units
2. Actuator Set Installation Work: 286 units
3. Door House Installation Work: 266 units
4. Fiber Optic Pole Installation Work: 3,115 poles
5. Fiber Optic Cable Installation Work: 126,600 meters
6. AWLR System Installation Work: 125 units
7. OPSHI Installation Work: 309 units
8. Dashboard Control Application Software work: 1 set
9. Command center installation work: 1 set Hardware
10. Electrical Power Connection Work: 266 points
11. Building Works and Equipment Control Room Jombang : 1 set
12. Building Works and Equipment Command Center Surabaya: 1 set

Implementation of Irrigation Modernization through Information Technology

Information technology (IT) with smart system in irrigation management is an integrated management system through digitalization of the main network in irrigation area with information technology-based planning, programming and implementation for sustainable benefits. The application of irrigation modernization through information technology is an integration between the first, second and third pillars of irrigation modernization (Mindiaستیwi & Pranida, 2023). Information technology devices and systems are used for automatic data reading, sending telemetry data, computerizing water balance calculations, telemetry door opening commands, and electromechanical operations (Afandi, 2020) (according to the five-principle of irrigation modernization). These devices are installed in regulating and discharging buildings and controlled by IT systems in the control room. Devices installed in regulating and discharging buildings are protected by sluice houses to maintain the safety of the devices inside. Sluice house detailed components as a follows.



- A. Perangkat Otomatisasi Pintu
- B. Panel AWLR
- C. Router

Aktuator Set

- 1. Gearbox
- 2. Reducer
- 3. Elektromotor
- 4. Kopling
- 5. Inverter
- 6. Panel penggerak

Figure 4. Sluice House Components

The main system functions consist of several subsystems:

1. Sensor/Data Capture subsystem

It has a function to retrieve data in the field related to irrigation networks. The purpose of this subsystem is to obtain the value of measurement parameters factors that affected irrigation system and obtained a realtime data. Data collection is done with sensors according to the needs such as:

- a. Water Level/Discharge: Measurement of water level or water discharge aims to measure the value of water in the irrigation network. Sensors that used are water level sensors (AWLR) or water discharge sensors/flow meters etc.
- b. Weather: Radar, rain gauge, temperature etc.
- c. Image: CCTV video.
- d. Land Readiness: Soil Ph sensor, soil moisture.
- e. Other sensors: Other sensors can be utilized in data collection in irrigation networks.

2. Data Storage Subsystem

It has a function to store and transmit data that has been obtained from both sensor data and IT process output. Considerations needed in data storage include scalability, reliability, redundancy, real-time, and security. These data can be used as:

- a. Water Level / Water Discharge: To verify the forcasted discharge, find out the real-time water losses from the difference in discharge upstream and downstream of the channel so the efficiency value of each channel is obtained for the irrigation water allocation plan. The actual water discharge used for the DSS process in accordance with the K factor. The water discharge is read in real time useful to fulfilling irrigation water needs according to real-allocation with optimal time and duration.
- b. Visual Data: To view conditions during operation, maintenance, breakdown, and safety.
- c. To control water delivery, plan availability and demand flows, water plans, etc.

3. Communication Network Subsystem

This subsystem is responsible for connecting all devices that enable data transmission and system control. This subsystem can use wired or wireless network communication, depending on the environmental terrain and operational needs. Considerations in communication networks include reliability, low latency, scalability, coverage, power efficiency, and security.

4. Actuator Subsystem

This subsystem consists of physical devices on the irrigation infrastructure for opening and closing operation of sluice gates (Patriadi et al., 2021). Actuators receive commands from the IT process subsystem/intelligent system and convert them into mechanical actions. Considerations in the actuator subsystem include responsiveness, durability, precision, scalability, power efficiency, and can be integrated with other subsystems.

5. Interface Subsystem

The User Interface (UI) subsystem in irrigation network systems serves as the primary medium of interaction between system operators, farmers, or other stakeholders and the central control system. It provides an easy-to-use platform for monitoring, managing, and controlling irrigation processes, offering real-time data visualization, system status updates, and manual control capabilities.

6. IT Process Subsystem

This subsystem serves as the control and command center of the entire Irrigation system. In this subsystem, data that has been obtained from sensors as well as commands and data entered by the operator is processed so it can be used in operating the irrigation system. This subsystem relies on algorithms and artificial intelligence to predict, optimize, and monitor the irrigation system.

Intelligent System Programming Process

1. Data Collection and Aggregation

This process involves collecting data from various sensors and external sources, including soil moisture sensors, weather stations, flow meters and satellite data. The data is aggregated and stored in a centralized database for further analysis.

2. Predicted Water Availability

This process estimates water availability for irrigation, taking into account factors such as reservoir elevation, rainfall, inflow, and evaporation. Predicted water availability helps to planning water distribution strategies.

3. Predicted Water Demand

This process estimates crop water requirements based on factors such as crop type, growth stage, weather conditions, and soil moisture levels. This ensures that water distribution matches the needs of the plants.

4. Water Distribution Optimization

This process determines the most efficient way to distribute water throughout the irrigation network, taking into water supply, demand and the physical layout of the system. The goal is to minimize water use while maximizing crop yields.

5. Malfunction/Anomaly Detection

This process monitors irrigation systems for signs of damage, leaks, blockages, or other anomalies that could disrupt water distribution. Early detection enables prompt maintenance and minimizes water loss.

6. Irrigation Control.

This process automates the execution of an optimized water distribution plan, controlling valves, pumps, and other actuators to deliver water as needed. This ensures that irrigation is done exactly as planned.

Early Warning System

Early Warning System (EWS) is a system which can detect, monitor, and provide early warning about potential flooding in area. EWS can open the floodgates automatically when the water level crosses the threshold (Santohana, 2024).

Internet of Things (IoT)-based Early Warning System prototype uses the following methodology (Noerhayati et al., 2022):

1) Hardware Design

Hardware design is as follows, all the required hardware then assembled into the desired characteristic form along with the desired mechanical design, electronics, program flow charts and program creation.

2) Software Design

The program writing stage is carried out after the desired tool design has been formed, this stage carried out to run the tool according to the characteristics of the tool has been designed.

3) Tool Testing

The program that has been made in such a way is stored and uploaded on the ESP 32 device and the blynk server, where the user uses the blynk application on his device. In the testing phase, it is used to determine the extent of the success of the tool that has been designed in accordance with the predetermined objectives.

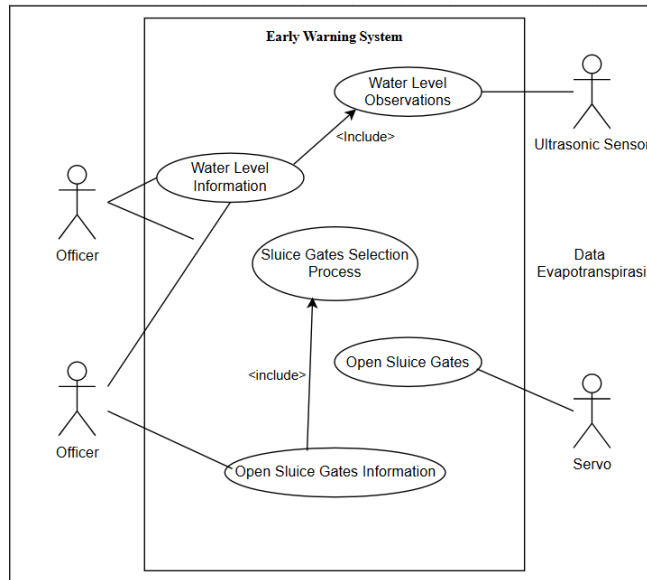


Figure 5. Early Warning System (EWS)

Table 1. EWS Component Description

Component	Description
Ultrasonic Sensor	Is a tool that detects the elevation or water level in the Irrigation Channel
ESP 32	It is a microcontroller that processes any input data from the components.
Servo	Is a tool that is in charge of opening and closing the floodgates.
Officer	Officer is the person in charge of maintaining and monitoring the Water Level (TMA) of the channel.

Research Relevance and Innovation

The digitalization of sluice gates offers significant advantages over the approaches implemented in previous research. (Samsugi et al., 2020) research focusing on an Arduino Uno-based automatic irrigation controller system, although it has helped farmers in controlling water levels efficiently, is only limited to the aspect of monitoring and controlling water locally. Similarly, (Abraham et al., 2024) developed a prototype of an Internet of Things (IoT)-based water level and flow velocity monitoring system, successfully provided real-time information through a smartphone. However, these approaches have not yet covered remote operation of sluice gates and integrating monitoring functions with automatic control, which are important aspects in supporting the efficiency and transparency of modern irrigation systems.

This research presents an innovation in the form of digitalization of floodgates that not only monitors, but also operates floodgates automatically and integratedly. Digital system allows controlling floodgates remotely through a command center at the BBWS Brantas Surabaya office or the UPI DI Siman Jombang office. With technologies such as Actuators, Automatic Water Level Recorders (AWLR), and monitoring cameras (CCTV), monitoring of water distribution becomes more efficient and accurate. This digitalization also helps reduce the risk of technical negligence, such as unequal water distribution, water diversion, or illegal water withdrawal. Officers no

longer have to conduct time-consuming and error-prone manual inspections, so the works become lighter and results are more optimized.

The importance of digitalization lies not only in technical efficiency, but also in its impact on the sustainability of irrigation systems and fairness of water distribution. With the transparency of data obtained in real-time, all interested parties, from officials to farmers, can ensure the water distribution was carried out evenly as needed. This is particularly relevant in the Siman Irrigation Area, where uncoordinated water distribution in the past often led to complaints and conflicts among farmers. Digitalization is therefore a solution that not only offers technical convenience, but also builds a more equitable, integrated and sustainable irrigation system. This research provides a significant step forward to challenges unresolved problem from previous research, while strengthening the basis for the importance of technology adoption in the irrigation sector in Indonesia.

CONCLUSION

The conclusion of this research is that the digitization of floodgates is a step towards modernizing the irrigation management system which aims to monitor the availability, needs, and distribution of water in real-time and enable more efficient and transparent remote control. This research identifies five important stages in the digitization process, namely the development of the Smart Irrigation System application, the automation of sluice gates, the modernization of irrigation based on information technology, the programming of smart systems, and early warning systems. These findings address the problems of manual irrigation, which still face many obstacles such as uneven water distribution, potential for fraud, and slow technical response. Digitization provides concrete solutions by increasing water management efficiency, reducing human error, accelerating problem handling, and supporting national food security. In the future, the contribution of this research can form the basis for the development of a broader smart irrigation system, including integration into secondary channels, as well as a policy reference in the sustainable modernization of agricultural infrastructure.

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