Guideline for planning ICT use in irrigation and drainage project

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Agricultural Development Consultants Association (ADCA)

Guideline for planning ICT use in irrigation and drainage project

Contents

Terminology

AI：Artificial Intelligence. AI is generally understood to mean "something that artificially reproduces various human perceptions and intelligence." However, in reality, there is no single definition of AI, and it is still being discussed from various perspectives, including computer science, cognitive science, medicine, psychology, and even philosophy. AI-based agriculture refers to the use of AI-based technology to improve the efficiency and added value of agricultural work and farm management. This makes it possible to reduce the workload, improve work and accuracy, and educate successors. The government is also supporting the spread of AI in light of the decline in agricultural workers and the need for a stable food supply. Agriculture that utilizes AI, IoT, and robotics technologies is collectively referred to as "smart agriculture."

API：Application Programming Interface. An API connects "applications that publish functions and data" with "applications that want to use those functions and data." By linking APIs, it is possible to embed functions from applications developed by other companies into applications developed by one's own company, and to share data and functions with each other. Programming is required when creating websites or software, but by utilizing APIs, it is possible to create them in a shorter period of time and at a lower cost than starting from scratch.

BWA：Broadband Wireless Access. Broadband wireless access allows wireless Internet connection by using radio waves in high frequency bands such as the 2.5GHz band. It can transmit large volumes of data at high speeds without wired lines, and has a wide communication area, so it is used to build wireless networks in large facilities such as factories. It is a wireless communication method suitable for sending and receiving large volumes of data, such as when monitoring agricultural land, canals, and other irrigation facilities with video. One base station covers an area with a radius of 2 to 3 km.

DX：Digital transformation. DX means that companies use big data and digital technologies such as AI and IoT to not only improve their business processes, but also transform their products, services, and business models themselves, as well as their organizations, corporate culture, and climate, thereby establishing a competitive advantage.

FA：Factory Automation. FA means automating factories. In addition to material processing, parts assembly, and product transportation in the production process, typical areas of application include management work. FA began to be adopted around 1950, with industrial robots coming into practical use around 1965, and robots that perform feedback control based on sensor information being developed in the 1970s. In the 2000s, the concept of Industry 4.0 emerged. Industry 4.0 utilizes technologies such as AI and IoT, aiming to improve manufacturing processes and increase production efficiency, leading to the realization of FA. With technological advances in both hardware, such as control devices and robots, and software, such as management and control systems, the aims of FA are also becoming more sophisticated.

5G：5G is a fifth-generation mobile communication system that realizes high-speed, large-capacity communication. Compared to the conventional wireless communication system 4G, 5G can realize "high-speed, large-capacity" communication by ultra-wideband transmission using high frequency bands, and has features such as "low latency" and "multiple connections". 5G networks have two operation methods: NSA (non-standalone) and SA (standalone). In particular, the SA method is a system configuration that updates the core equipment and base stations to 5G technology, so it is possible to fully utilize 5G functions. By shortening the communication start time and combining wideband frequency bands, communication speeds, especially upload speeds, can be significantly increased. Furthermore, the SA method enables advanced network control. 5G can be used for remote monitoring of unmanned agricultural machinery, which requires low latency communication, and crop growth diagnosis that combines high-definition images and AI.

FOEAS: Farm-Oriented Enhanced Aquatic System. FOEAS is not only a system that can wash away mud and sand that has accumulated in the underdrain pipes and a conventional drainage function, but also has an irrigation function that uses an underground adjustment valve. By introducing it, it is possible to prevent both over-humidity and drought damage, making stable crop cultivation possible.

Gateway : Gateways mediate communications between different types of devices and networks, converting protocols and ensuring security. They are particularly useful when different IoT devices operate cooperatively on the same network. In an IoT environment, multiple devices and protocols co-exist, so routers and gateways work together to ensure smooth communication. This allows different IoT devices to work together effectively, and data collection and control are carried out smoothly. Routers and gateways are often used at the same time, and there are many products that have both functions.

ICT ： Information and Communication Technology. ICT is now widely used instead of IT (information technology), which was previously used. IT referred to technology and devices that used digital data, but in recent years, with the spread of the Internet and advanced communication infrastructure, the amount of digital data exchanged has increased enormously, so the word ICT has been used, adding the word "communication" (C) to IT.

IoT : Internet of Things. IoT is a mechanism in which various things that were not previously connected to the Internet (sensor devices, actuators, homes and buildings, cars, home appliances, electronic devices, etc.) are connected to servers and cloud services via a network and exchange information with each other. By utilizing IoT technology, it will be possible to create higher value and services that have never been seen before.

IoT router : In IoT, a router is a device that forwards data packets within a network, manages the internal communication between devices, and provides a precise path for data within the network.

IP ： Internet Protocol. IP is a protocol for data communication over the Internet. When transferring data, IP divides one piece of data into units called packets. A packet consists of an IP header, which stores information such as the IP addresses of the sender and receiver, and a payload, which stores the content of the communication data. In IP communication, packets are sent to a terminal on the other network based on the "IP address" that identifies the communication partner.

LPWA ： Low Power Wide Area. Wireless communication technology characterized by low power consumption and wide-area/long-distance communication. Although the amount of communication data is small and the speed is slower than Wi-Fi, wireless communication over distances of over 10 km is possible. The use of IoT and M2M in smart factories, logistics, agriculture, housing, and life infrastructure requires long-distance communication of small data such as sensor values output by IoT devices installed far away, data for identifying positions, and control data sent to devices, so LPWA wireless communication technology is the foundation for these. The battery life of LPWA modules is over 10 years, so the frequency of battery replacement in IoT devices can be dramatically reduced. Data such as temperature, water levels in canals, and paddy fields collected by sensors can be connected to the Internet, making it a low-cost wireless communication suitable for realizing IoT on agricultural activities.

M2M : Machine to Machine. A mechanism by which machines interconnected by a network communicate and function. This refers to a mechanism by which interconnected things, such as not only information devices like computer terminals and servers, but also manufacturing equipment in industry and home appliances in households, have the ability to communicate autonomously through a network, and automatically control and optimize things by exchanging information between them without human intervention.

PLC : Programmable logic controller. PLCs are control devices used in large-scale facilities such as production equipment, as well as familiar facilities such as elevators, automatic doors, and amusement park attractions. PLCs are used to connect to multiple input/output devices (switches, sensors, motors, solenoids, lamps, etc.) to ensure that they operate as intended. For production equipment, PLCs are developed on the premise that they will meet the requirements necessary for production equipment, such as environmental resistance, ease of maintenance, stability, and the ability to connect to large number of input/output devices. As PLCs use software to achieve control, a single unit can handle complex processing, and I/O (Input/Output) can be selected and expanded in units, allowing users to select and use units according to the peripheral devices they want to connect.

SCADA：Supervisory Control and Data Acquisition. A system that collects information obtained from the devices and equipment that make up large facilities and infrastructure in one place via a network, monitors it, and controls it as necessary. This makes it possible to check and control the status of all the devices scattered throughout the facility at glance. For example, in the case of water and gas infrastructure, SCADA can collect information such as the flow rate and pressure of water and gas passing through water and gas pipes in each area, and if an abnormality is found, it can issue an alert and prompt a response.

SSL：SSL (Secure Sockets Layer) is a mechanism (protocol) that encrypts and transmits data between web browsers and web servers on the Internet. Site administrators can protect transmitted information from malicious third parties while at the same time verifying that the transmitted information has not been tampered with. An SSL server certificate is an electronic certificate that "verifies the existence of the operator" of a website and "encrypts communication data" between browsers and web servers, and is issued by certification authorities such as GMO GlobalSign.

TC：Telecontrol. The remote control of sensors and measuring instruments at observation points.

TM：Telemetry. Remote measurement. This is the measurement of data transmitted from an observation point via a communication line at a location away from the observation point. Sensors are used to collect electrical data (such as voltage and current) and physical data (such as temperature and pressure). This data is transmitted to a remote location for monitoring and analysis, enabling effective management and control of the system.

UI：User Interface. UI refers to the operation screen and operation method of a device or software that a user is in contact with when exchanging information with a computer. In hardware, it refers to the keyboard, mouse, display, etc., and in software, it refers to the operation method of the menu, icons, windows, etc. on the screen.

VPN：Virtual private network. Connecting to the Internet through a VPN is called a VPN connection, but because it is "virtual," it uses various technologies to treat the shared line as if it were a virtually independent dedicated line. A VPN connection can be likened to driving a private car on a road that everyone uses. The road itself is shared, but privacy and security are guaranteed to a certain extent within the fixed space of the car. In other words, it is more cost-effective than laying a physical dedicated line, while ensuring safety compared to using a shared line normally. It is used to strengthen the security of the communication environment when using public Wi-Fi that can be connected for free or when connecting LANs between multiple locations.

1. Introduction

In irrigation water management in Asia, there is a shortage of personnel in water users' associations (WUAs) and other organizations that manage water as a result of economic growth. There is also a demand for efficient water distribution management with a small number of people, and as the scale of agricultural management increases, there is a demand for labor-saving water intake management so that farmers can concentrate on agricultural management. In order to ensure sustainability and improve productivity in agricultural management at the same time, it is essential to develop an environment where data on water levels, rainfall, etc. can be used efficiently to carry out efficient water distribution and intake management.

This guideline compiles basic concepts and points to consider when building project plans, and when constructing telemetry (TM) monitoring systems for water levels, rainfall, water quality, etc. related to agricultural water supply, distribution, and drainage in Southeast Asia. This TM system includes ICT technologies such as automatic water taps at the field level and mutual correspondence between systems.

This guideline is aimed at government organizations, water users' associations (WUAs), and farmers responsible for managing agricultural water and maintaining facilities, as well as ICT manufacturers, consultants, ICT manufacturer agents in developing countries, and organizations that support the introduction of irrigation and drainage information infrastructure and systems. This is intended for cases in which these organizations are considering the introduction of ICT technology as a means to enhance the labor productivity and efficiency of water management, save water use, accurately manage water distribution, and improve the efficiency of disaster response.

This guideline also describes the challenges and effects of introducing ICT into water management, as well as basic concepts and points to note about ICT introduction, based on case studies to date.

(1) Users of the Guideline

This guideline is intended to serve as a practical reference for government organizations, WUAs, and farmers responsible for managing agricultural water and maintaining facilities, as well as ICT water management equipment manufacturers (manufacturers of sensors, communications, cloud services, software, etc.) considering the expansion of irrigation water management TM systems in Southeast Asia, consultants, local agents of ICT manufacturers (trading companies, local manufacturers, vendors, etc.), and support organizations for the introduction of ICT water management systems (JICA, international development financial institutions, etc.) (Figure 1.1).

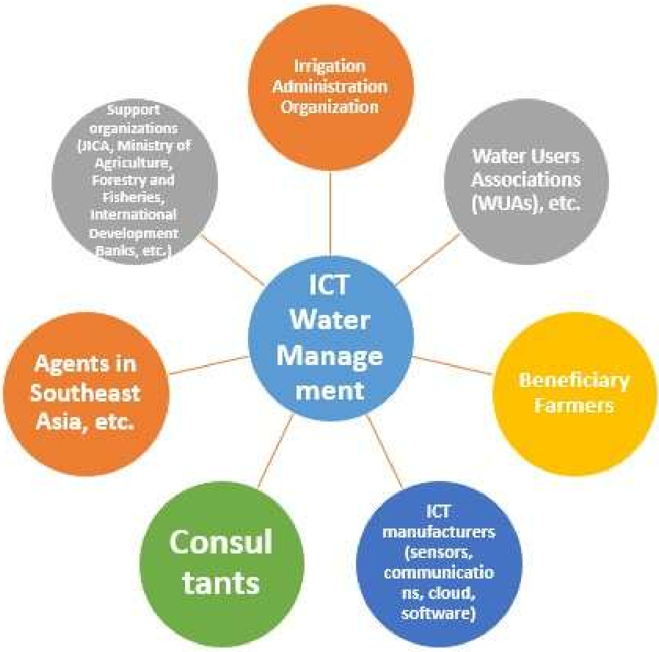


Figure 1.1 Scope of the users of the guideline

(2) Scope of this guideline

This guideline shows the points to note for each process in the series of steps for deploying ICT irrigation water management in Southeast Asia. Examples of this process are shown below. In practice, it is expected that users will select and refer to the processes that apply to them.

(i) ICT water management technology
(ii) Basics for introducing ICT water management
(iii) Introduction of ICT water management technology

- Selection of ICT water management technology
- Consultation with relevant organizations
- On-site survey and design, etc.
- Installation of ICT water management equipment
- Data analysis and consideration of improvements to water management systems

(iv) Post-project maintenance

(3) Handling of terminology in the guideline

ICT water management technologies aim to automate irrigation. Irrigation automation is implemented by SCADA, a broad and constantly evolving set of electronic hardware, computer software, and communication infrastructure that provides a platform for remote monitoring and control in a variety of industrial applications (Brian et al. 2014). SCADA in irrigation ranges from simple systems where an operator monitors water levels or flow rates over a TM network to large-scale systems that can automatically control large-scale irrigation water management over a communication network. Regardless of the size of the irrigation, SCADA can provide real-time monitoring, remote monitoring or automatic control, warning or emergency notification, troubleshooting, and automatic data reporting and archiving functions.

As irrigation development is progressing in Southeast Asia, SCADA will be introduced to existing irrigation facilities. When introducing SCADA, it is necessary to clarify and quantify the project objectives of SCADA, including improvement of irrigation services, water conservation, appropriate control of water levels, reduction of operating costs, and appropriateness of return on investment. In particular, it is important to consider the following: (1) reducing the cost of infrastructure investment for SCADA by effectively utilizing existing irrigation facilities, (2) operation and maintenance of SCADA, (3) establishment of an irrigation water management system based on SCADA, and (4) securing the maintenance and renewal costs of SCADA. SCADA operators are required to be able to adapt to new equipment and software, and to respond appropriately to alarms and operational problems, so human resource development and continuous training are essential. Despite large investments, there are many cases where SCADA does not function adequately, mainly due to unclear introduction objectives and overlooking issues in operation and maintenance, including securing human resources.

This guideline focuses on ICT technologies that contribute to SCADA as a whole, so the term ICT rather than SCADA is used. In Southeast Asia, there are a lot of TM systems that have been introduced to main irrigation facilities such as dams, and TM is considered to be part of ICT technology. Technological innovations are progressing in telecontrol (TC), and this is also considered to be part of ICT technology. ICT is an evolution of IT, so the term IT is not used.

In Japan, the construction of base stations for satellite positioning systems related to location information for smart agriculture is underway, but in Southeast Asia, the autonomous driving of agricultural machinery has not yet progressed, so there is no need to construct base stations for project purposes. The base stations in this guideline refer to those installed by mobile phone carriers.

2. ICT Water Management Technology

2.1 Use of ICT technology in water management

To address basic issues in water management like mismatched water demand, it is important to restructure each component of the irrigation system (canal system, organization, order, etc.) in a well-balanced manner according to the local situation.

In carrying out this restructuring, it will become more important to utilize ICT technology for efficient water management. For example, to address current issues, by utilizing ICT technology in addition to improving the function of facilities, it is expected that the burden on water management organizations will be reduced and water use order will be improved while responding to changes in water demand.

When utilizing ICT technology, it is important to consider with stakeholders the future vision of regional agriculture and the state of the canal system and water management system (organization, order, etc.) that supports it, taking into account costs, effectiveness, and efficiency.

In addition, if ICT is introduced all at once from the upstream main canal to the fields, it may cause confusion in the organization and order of the current water management system, so it is desirable to introduce it in stages.

ICT water management technology is divided into (1) main water management system (Main-WMS), (2) water distribution management system (Distribution-WMS), and (3) field water management system (Field-WMS).

The followings are examples of the use of ICT technology in water management:

- Remote monitoring of canal systems at the main, branch and terminal levels
- Introduction of remote operation and automatic control systems
- Installation of multi-function automatic water taps and valves in fields
- Interoperability between these systems
- Sharing of water supply and demand information between facility managers and farmers

When introducing ICT systems, the impact and effect of the ICT technologies on the overall water management will vary depending on the level of the target canal system (main canal, branch canal, terminal canal, fields), its scope, and whether or not data is shared between each level. It is desirable to introduce ICT appropriately according to the current state of water management in the region, and it is necessary for stakeholders to thoroughly discuss whether the ICT can be a solution to the issues.

The most ICT-based water management is one in which ICT is used to support (1) the Main-WMS (TM/TC), (2) the Distribution-WMS, and (3) the Field-WMS, together with information/communication and control technology.

The terminal field water management system uses ICT to enable remote monitoring of the water depth at the fields, and remote operation of water supply and drainage valves. The water distribution system realizes efficient water distribution by introducing remote monitoring and control of distribution facilities such as pumping stations managed by WUAs, automating water distribution, and simulating optimal water distribution. A new water management system will be established by utilizing ICT to share information between the water taps and water distribution facilities in paddy fields managed by farmers. At the top of the systems is the Main-WMS that manages regional water using main irrigation facilities. By sharing information aggregated at the branch canal level, it will be possible to link the Main-WMS to water management for the entire river basin (Figure 2.1).

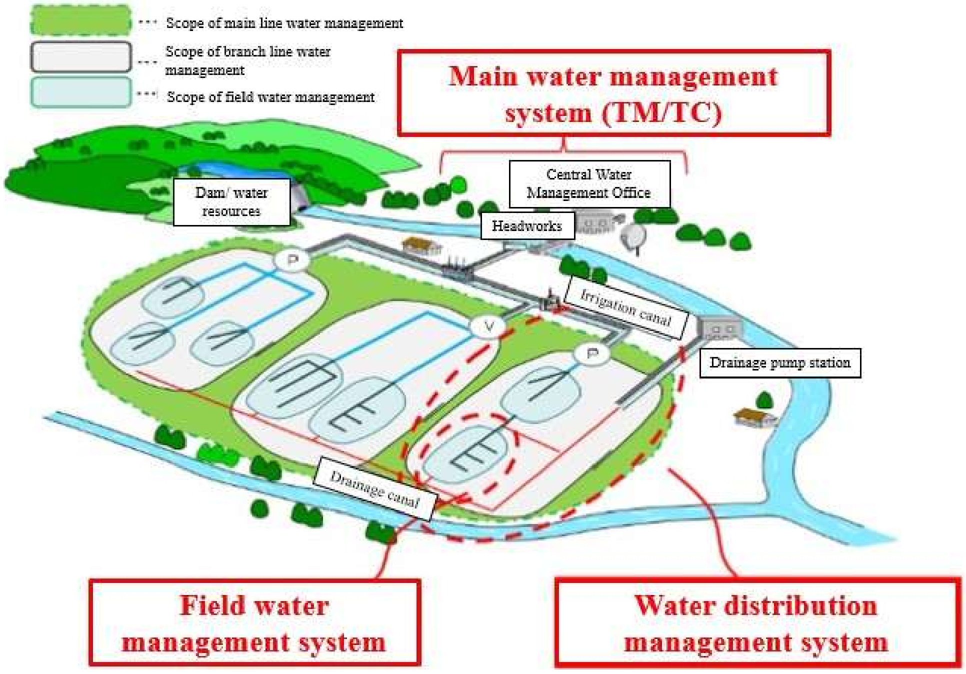


Figure 2.1 Conceptual diagram of water management system (NIRE. 2019)

The outline of the water management system for the facility is shown below. Figure 2.2 shows the conceptual diagram of the layout of ICT equipment in the most advanced water management system.

(1) Main-WMS (basic water management system: managed by government agencies or WUAs, etc.)

The Main-WMS is a water utilization system established by a national or local government agency and managed by the government agency or WUA. It consists of water source facilities such as dams, head works, and pumping stations, and water distribution facilities such as main and branch canals and large-scale diversion works. Water management systems that monitor and operate these facilities vary from standalone systems to complex systems, but basically, the supply side (WUA, etc.) adjusts the amount of water based on a water use plan.

(2) Distribution-WMS at the branch level (managed by WUAs, etc.)

The Distribution-WMS is a system that takes over from the Main-WMS and delivers water to farm fields, and is managed by WUAs and water user groups (WUGs). Here, this is assumed that the water to the system is supplied from the Main-WMS, and that the water distribution by the water distribution facilities is managed by local WUAs and WUGs. As TM/TC is not installed, it is operated manually according to the water demand of farmers.

By introducing TM/TC, automation of water distribution, and optimal water distribution simulation, it is expected that the patrol and operation labor of WUAs and others who manage the canal system will be reduced, and enabling efficient water distribution management by reducing ineffective discharge.

(3) Field-WMS (managed by farmers)

Water is supplied from the Distribution-WMS at the branch canal level, and farmers manage the water at the field level. Although direct working hours for rice cultivation have decreased due to progress in land consolidation and the use of larger agricultural machinery, there has been no progress in reducing water management working hours. It is expected that the introduction of remote water level monitoring devices and multi-function automatic water taps will reduce the labor required for farmers to patrol and manage water.

In addition, it is expected that system linkages, such as enabling automatic operation of pumps depending on the operating status of the multi-function automatic water taps in the field, will reduce ineffective discharges and reduce electricity costs. It is expected that a semi-demand-driven system will be created by farmers and WUAs sharing information in real time and making water management two-way, allowing WUAs to supply water according to demand of farmers to carry out planned farming.

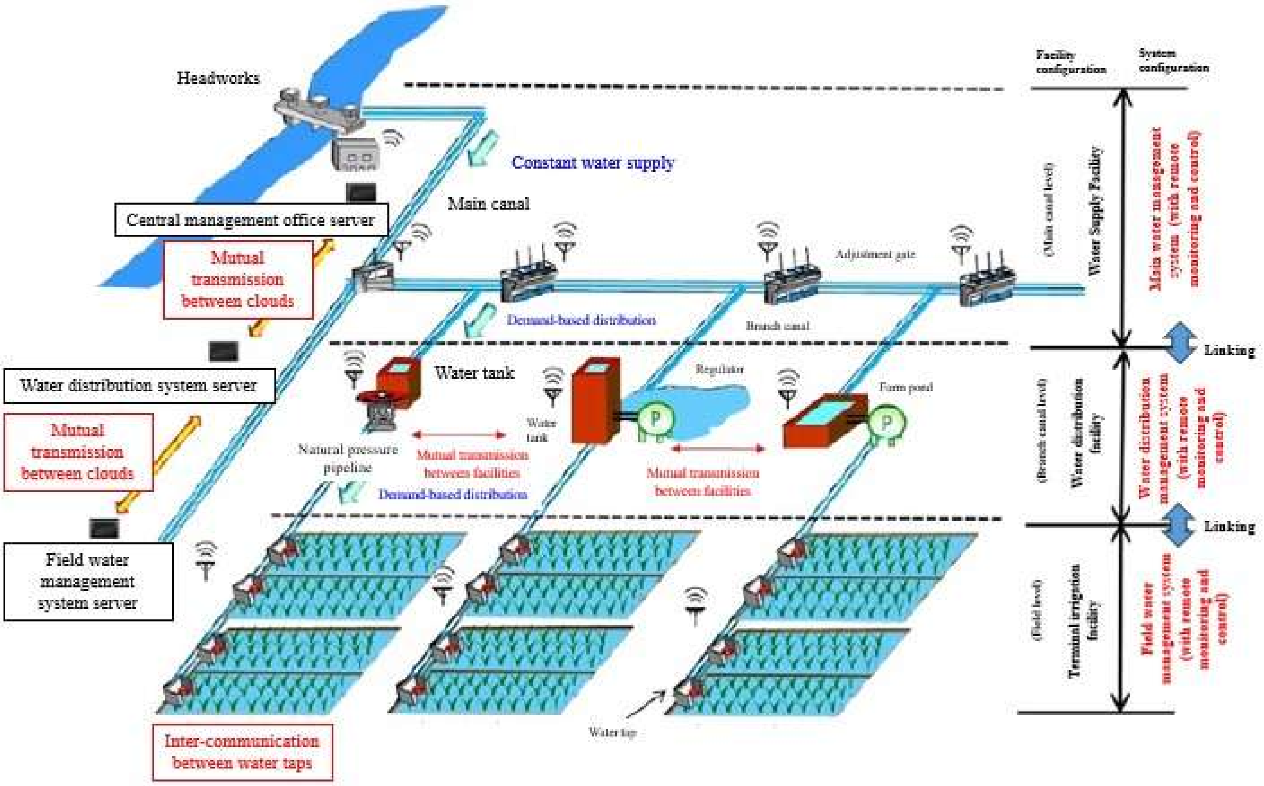


Figure 2.2 Schematic diagram of the layout of ICT equipment in the latest water management system (NIRE. 2019)

2.2 Main Water Management System (Main-WMS)

Current status of the Main-WMS

- Many of the water management systems constructed in large-scale irrigation projects are managed by multi-layered water management organizations, mainly WUAs.

(1) Design of the Main-WMS

Regarding the amount of water required for paddy field irrigation, the gross water requirement, which is the basic unit of agricultural water, is calculated by accumulating the water requirements per field (including the amount of water required for cultivation management), subtracting the effective rainfall to obtain the "net water requirement," and then adding the amount of water required for facility management. From this, the amount of water required for paddy field irrigation is determined by subtracting the amount of water available within the beneficiary area. The amount of water required for agricultural use is determined by adding the amount of water required for paddy field irrigation to the amount of water required for other purposes (regional water, etc.).

On the other hand, the water source development plan is made by comparing the amount of water available at the water intake point with the amount of water required for the water use plan, and if the amount of water available is insufficient, the water requirement is leveled out or new water sources such as reservoirs and regulating ponds are considered.

From the above, the main facility plan is formulated within the scope of the water source plan in response to the water demand. If the water source is a limiting factor, the demand is adjusted, or an irrigation system is constructed by installing regulating facilities.

(2) Multi-layered management structure

Water management in large-scale irrigation project areas is carried out by a multi-layered management organization centered around the WUA.

Impact of the introduction of the latest water management technologies on the main irrigation system

- With the introduction of the latest water management technology, the main irrigation system will need to strengthen its supply and demand adjustment capabilities through its water management system. The main irrigation system is responsible for satisfying the water supply from the water source to the branch canals so as not to interfere with water use at the those canals, and is fundamentally required to have the adjustment capacity to respond to fluctuations in demand at the branch canals or below, and redundancy against disasters and drought risks.

(1) Relationship with the water management system of the main irrigation system

The main irrigation system is assumed to be a irrigation facility installed in a large-scale irrigation project and managed by a WUA or other organization. This irrigation system generally consists of headworks (or pumping station), main canals, and major diversion works. Remote monitoring and control (TM/TC) is installed at the major diversion works (sometimes only TM is installed). Other small-scale facilities are often operated manually on-site by facility managers who are assigned to there. This irrigation system adopts a supply-driven water management method based on water rights to take water from the water source (rivers). Large-scale irrigation systems managed by WUAs are equipped with water management systems equipped with TM/TC devices. The configuration of the water management system is determined by considering the system design, such as the management level of the water management facilities, the system importance classification, the system configuration, and the monitoring and control method. The necessity of installing TM/TC for facility management is considered not only by the importance of the facility but also by economic efficiency. Generally, TM/TC is installed only at major irrigation facilities, and other facilities are operated on-site. Each branch canal is managed by a water management manager, and the water management of each branch depends on the skills and experience of the manager.

As the agricultural structure changes dramatically, WUAs are also required to respond to the fact that they can no longer expect farmers to provide labor for facility management. In terms of water management, it is becoming difficult to secure water management personnel for each branch canal. ICT technology makes it easier to share information, so it is necessary to reduce the number of patrols by digitizing and sharing water management information, as well as to increase the number of TM/TC installation locations, automate gates, and otherwise improve the sophistication of water management systems, e.g. by making canals into pipelines, in order to reduce the management labor of WUAs.

(2) The way to develop the Main-WMS

The introduction of ICT water management technology below the branch level may require new development in the Main-WMS. On the other hand, the need for restructuring and development of the main irrigation system increases as water demand changes and deterioration occurs over time, so it is advisable to consider both.

<u>Ensuring coordination between upstream and downstream</u>

When main irrigation systems are operated as open canals, problems such as inequality, and ineffective discharge of water between upstream and downstream often occur. Measures to solve these problems include the construction of main canal regulating reservoirs, the installation of main canal check gates, the construction of pipelines, and the use of TM/TC.

<u>Ensuring adjustment capability of main canal with branch canal</u>

In the current situation where the water demand of the terminal field irrigation system is about to change significantly, the issue of ensuring the supply and demand adjustment capacity between the main canal and the branch canal will become increasingly important in the future. Measures to address these issues include the installation of farm ponds, reorganization of pumps, pipelining, and the use of TM/TC.

<u>Ensuring redundancy in infrastructure</u>

Because the main irrigation system is the key infrastructure for the water supply of the region, if it stops functioning due to a disaster, there is a risk of causing severe damage to the entire region, so ensuring a certain degree of redundancy in the facilities to be developed is an issue. Possible means of dealing with this issue include bypass canals, double canals, irrigation and drainage canals, repeated use of irrigation water, operation of existing regulating reservoirs and dams, and utilization of TM/TC.

Ensuring independence at the branch canal level

Ensuring freedom and independence of water use at the branch canal level based on terminal water demand will be important in the future.

Regional infrastructure asset management

The main irrigation system is a regional asset. It is necessary to take advantage of opportunities such as renewal works to promote sustainable facility management (asset management).

2.3 Water Distribution Management System (Distribution-WMS)

Definition of the Distribution-WMS

- Distribution-WMS is a system that manages water at the branch canal level, automating and remotely monitoring and controlling the distribution of water from water distribution facilities such as pumping stations, distribution tanks, regulating ponds, and valves to fields according to water usage in the fields.

Distribution-WMS treats everything from the water supply points managed by farmers to branch canals and water distribution facilities such as pumps and valves that cover an area of 10 to 100 hectares managed by WUAs as a single system, and introduces a simplified monitoring and control/information collection system to automate and remotely operate water distribution and facility management using computers, tablets, smartphones, etc.

This system makes it possible to monitor and control water distribution facilities managed by WUAs and end-of-field water taps managed by farmers in a single system, thereby not only reducing the water management workload of farmers but also contributing to a reduction in water consumption and labor savings in irrigation facility management (Figure 2.3).

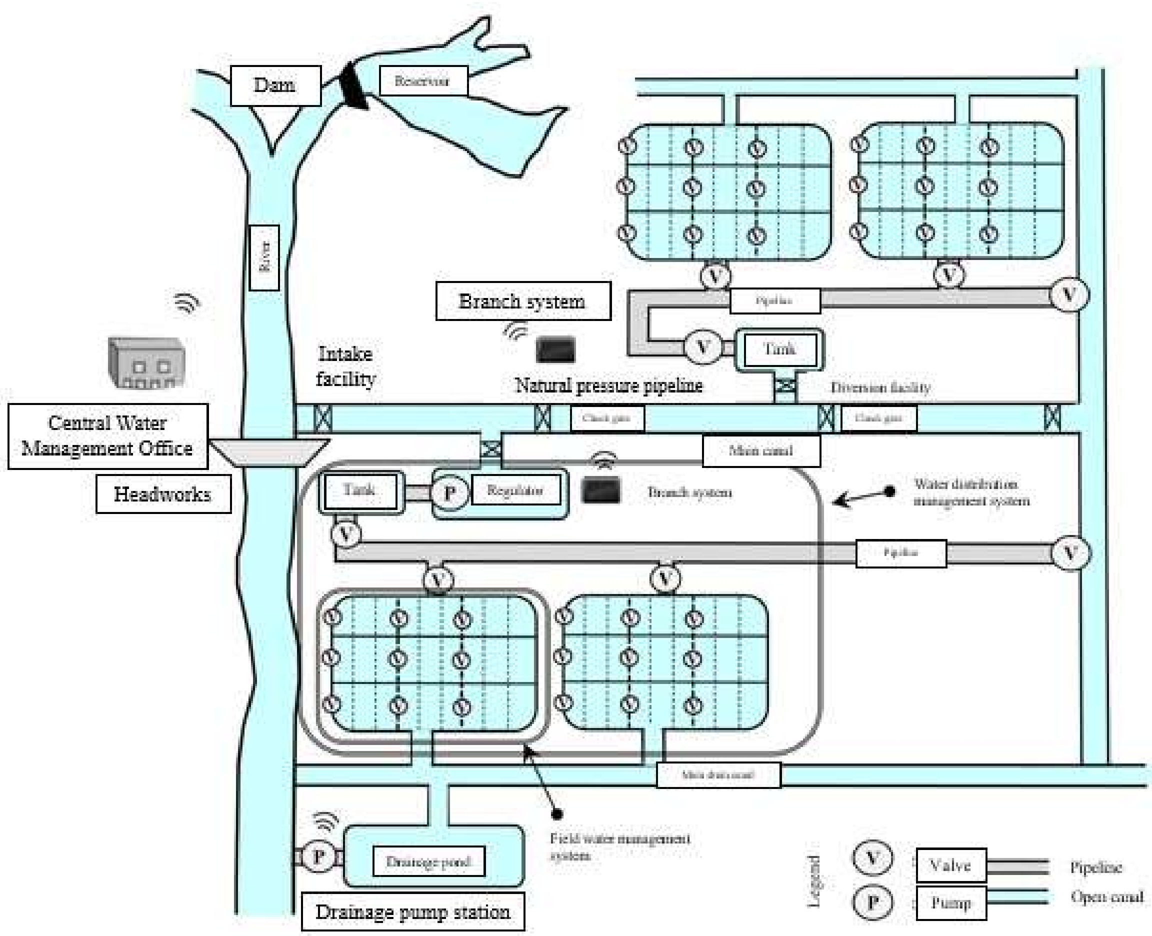


Figure 2.3 Distribution-WMS linked from dams to farm fields (NIRE. 2019)

Configuration of Distribution-WMS

- Distribution-WMS is a package that includes a programmable logic controller (PLC) that controls remote monitoring and devices, and a communications infrastructure (mobile phone network, low power wide area communication (LPWA), etc.). The Distribution-WMS performs appropriate water distribution control taking into account the water usage situation in the fields. The server is based on cloud management and supports both web browser management and on-premise management in an office.

The main components of the Distribution-WMS are as follows:

(1) Monitoring and control equipment

It is possible to remotely control everything from existing pumps to newly installed automatic valves. It is also possible to remotely monitor sensors such as water level gauges, flow meters, and pressure gauges.

(2) Controller

The control equipment installed on-site is managed by a general-purpose controller called PLC.

(3) Server

As shown in Figure 2.4, it is based on cloud server management and can be operated both via a web browser for farmers and facility operators, and on a PC in the WUA office. If a physical server is not staffed by a system engineer, security issues are likely to occur, and maintenance and update costs are expensive, so careful consideration is required before introducing it.

(4) Monitoring terminal (user interface)

Both of an office PC and a web browser-based smartphone can be used. Both types need to be designed to be intuitive for farmers, with graphical status displays and the ability to accomplish purposes with fewer operations.

(5) Communications infrastructure

IoT routers installed at each pumping station connect to the cloud via a mobile communication network. Distributed monitoring and control devices, such as monitoring equipment at the regulating facilities around the pumping stations, are consolidated in one place at the IoT router using the LPWA, reducing communication costs (Figures 2.5 to 2.7).

(6) Control software

SCADA is used, which is standard for factory automation (FA) and plant monitoring, and provides reliable and stable monitoring and control. Also is used web browser-based software with almost the same functions as SCADA.

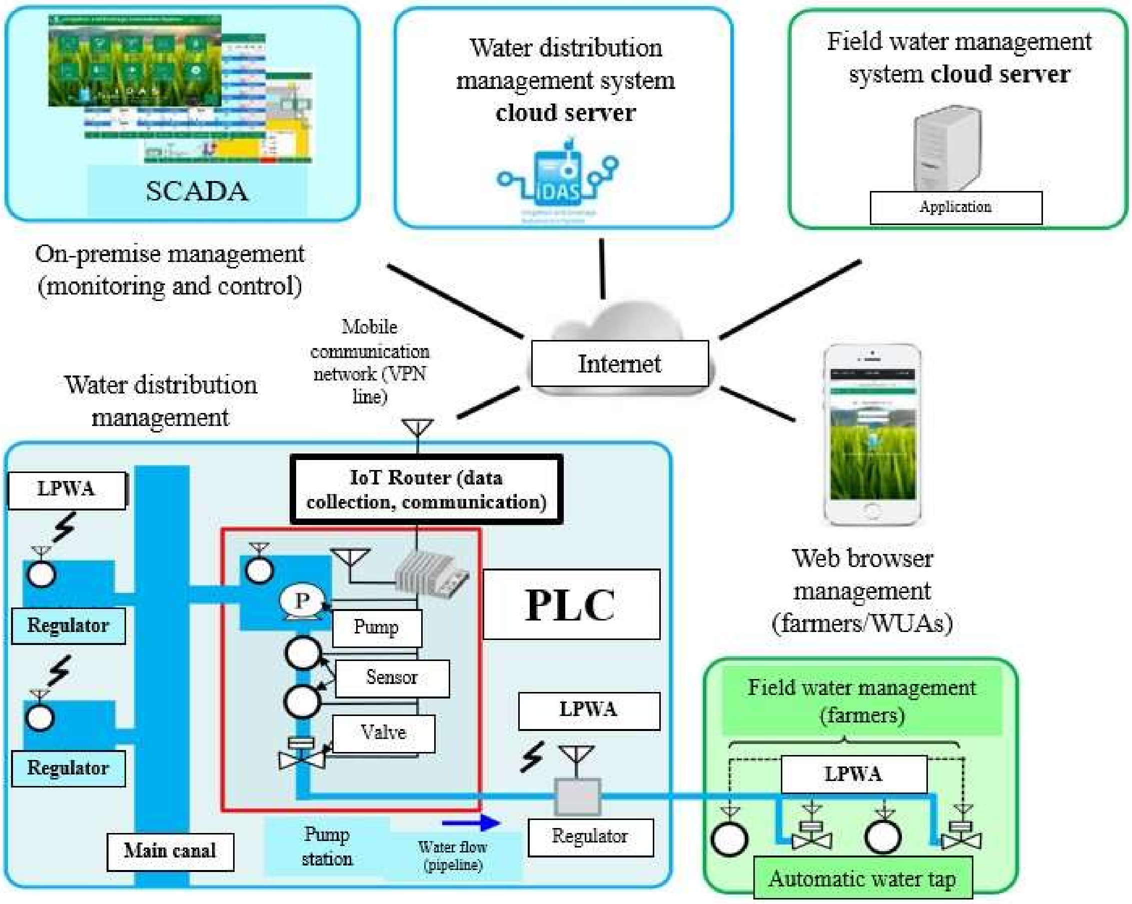


Figure 2.4 Configuration of Distribution-WMS (NIRE. 2019)

Figure 2.5 Objects of monitoring and control (left: farm pond and pumping station, right: water level monitoring of water tank) (NIRE. 2019)

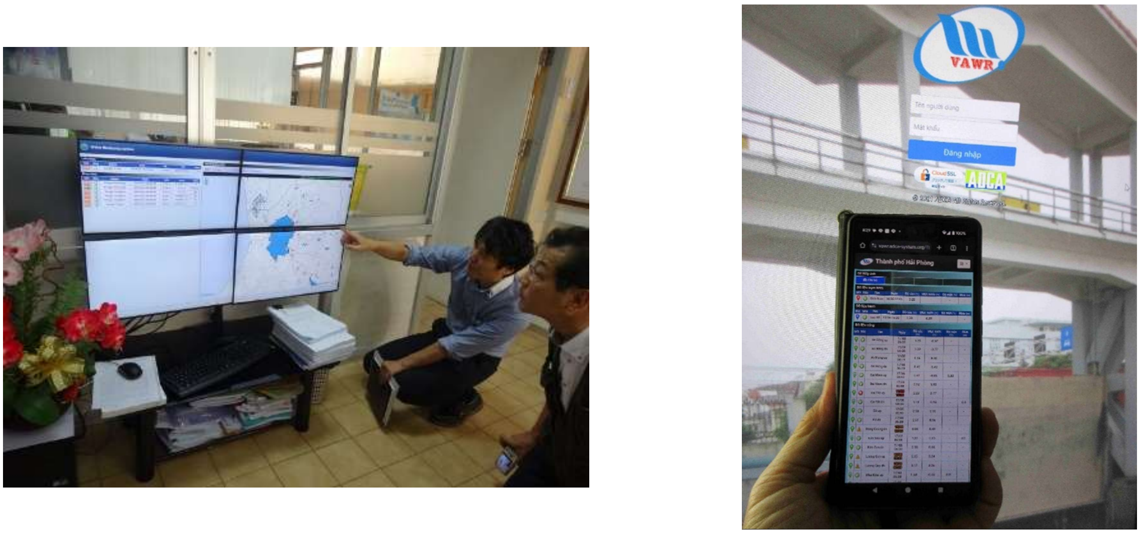


Figure 2.6 Monitoring terminals (left: office PC, right: farmer/facility manager smartphone)

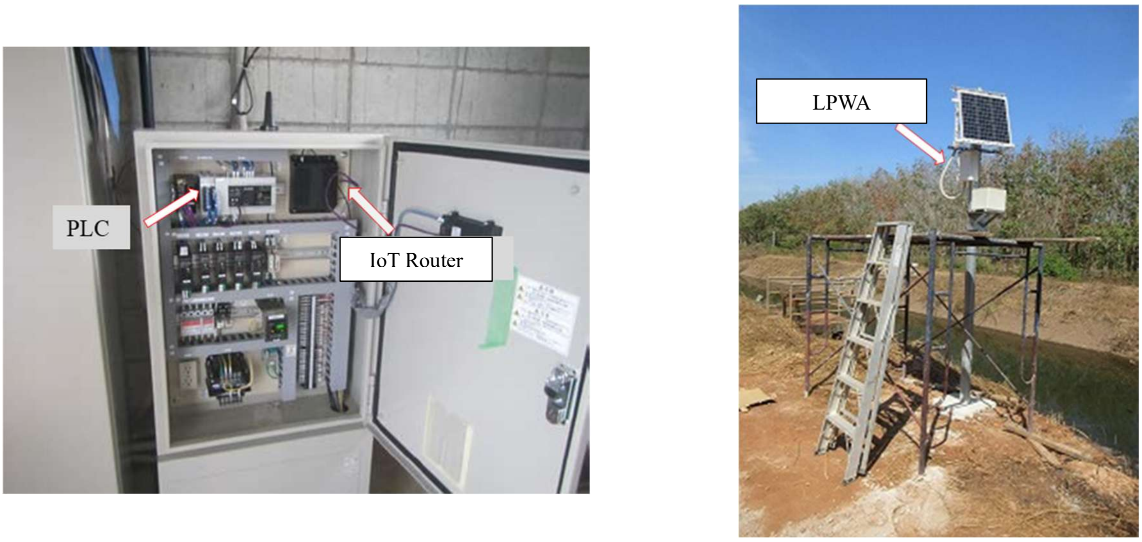


Figure 2.7 Communication control devices. Left: PLC and IoT router (NIRE. 2019),
right: LPWA communication device.

【Reference】Communication range of LPWA

LPWA communication equipment from Farmo Co., Ltd. was introduced to Thailand and Vietnam. The specifications of this communication equipment are as follows:

Specifications	Photo
■ Operating temperature: -15℃ to 40℃ ■ Farmo main unit: LPWA (LoRa modulation) between communication device (GW) ■ Communication device: LTE communication between the Internet ■ Communication standard: External dimensions (width x depth x height) of approximately 60 x 55 x 220 cm ■ Power source: Lead-acid battery ■ Charging method: Solar power generation ■ Simple waterproofing	

The communication range of Farmo's LPWA on the plains of Thailand was unstable, but was possible up to 2.7 km, depending on the number of obstacles on the ground (Figure 2.8). However, for stable communication, a range of 2.0 km or less was considered appropriate. In the durian and rubber plantation areas of the hills of Thailand, forests created obstacles, limiting the communication range to less than 0.5 km.

On the plains near Hai Phong City in Vietnam, data transmission was possible from a water level sensor installed 1.7 km from the communication device, despite the presence of many buildings (Figure 2.9).

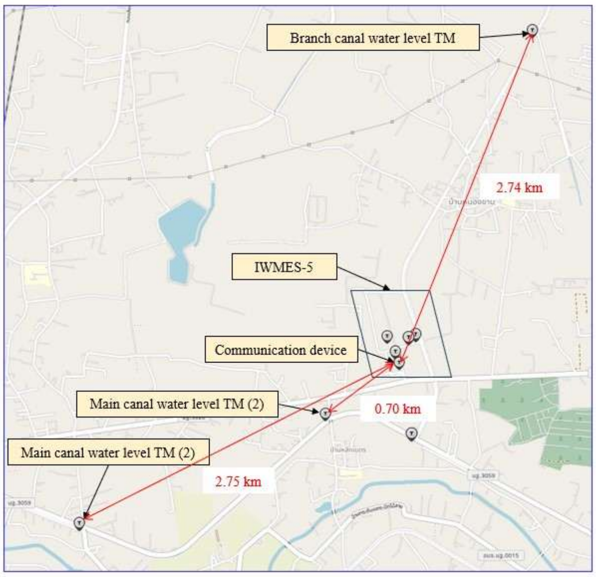


Figure 2.8 LPWA coverage in the plains of Thailand

Figure 2.9 LPWA coverage in Vietnam

Functions of the Distribution-WMS

- By using ICT to link water distribution facilities such as pumping stations managed by WUAs and water taps for rice fields managed by farmers, and remotely monitor and control them, the Project can optimize the distribution of agricultural water, reduce the labor required for water management, and conserve water and electricity use.

The main functions of the Distribution-WMS are as follows:

(1) Data collection, display and browsing

Collects and displays graphs of control information such as the operation status of water distribution facilities and data from multiple sensors that monitor the facilities.

(2) Remote control

Remotely control the ON/OFF of water distribution facilities, and remotely set automatic control modes.

(3) Water distribution control function

Multiple water distribution control methods can be selected, enabling automatic control. The main water management methods are as follows:

Constant control function of maximum pressure loss

In a direct-delivery pumping station, the pump is controlled by an inverter so that the pressure at the point where the pressure loss is maximum remains constant, regardless of the open/close status of all water taps, based on hydraulic analysis of the distribution pipeline that was conducted in advance.

Constant step control of water tank water level

In a water tank with a small adjustment capacity, the flow rate is calculated from the rate at which the water level drops, and the water distribution from the pump is controlled by an inverter according to the flow rate used.

Time Control

Information from the farm management system, water supply schedules from facility managers, and wide-area facility management information are collected on a cloud server, and the operation start times of water distribution facilities (pump stations) are controlled based on this information.

Optimal valve opening simulation function

The valve opening of each water tap to a specified value is proposed to set the amount of water supplied to all fields operated by a management entity when the management entity manages everything from the water distribution facility to the water taps of the fields, based on hydraulic analysis of the water distribution pipeline.

(4) Alarm system

On the monitoring screen, an alarm will be issued if there is an abnormality in the water distribution facility or if the actual values differ from the various settings. A warning notification (email) will also be sent to the designated administrator.

(5) Linkage with field water management system

By installing automatic water taps that can be remotely monitored and controlled in the fields where water is distributed, information can be collected wirelessly and sent to the water distribution facility.

(6) Preparation of daily, monthly and annual reports

Various water management data (regulating tank water level, pump operation status, set values, control commands) are output every hour as a daily report. Monthly reports compiled by day and annual reports compiled by month are also output.

(7) Linkage with various external applications

Linking with external applications and databases such as farm management systems and weather forecast data in real time.

(8) Application to drainage pumping stations

Some drainage pumping stations operate the pumps automatically according to the water level of the suction tank or the flood control basin, but many pumps are operated manually by WUA staff. In such pumping stations, a water distribution management system can significantly reduce the management effort.

In order to decide when to start pumping for flood drainage and to notify related organizations, it is necessary to predict the rise in the managed water level during flood warning. This can be done by creating a separate prediction program and utilizing the Distribution-WMS.

Effects of introducing Distribution-WMS

- The introduction of Distribution-WMS will enable a significant reduction in the amount of water management work required. In addition, by controlling water distribution in response to water usage, it will enable water and electricity saving.

The main effects of introducing Distribution-WMS are as follows:

(1) Labor-saving effect of facility management

The introduction of Distribution-WMS enables remote and automatic control of water distribution facilities such as pumping stations. This minimizes the need to visit multiple water distribution facilities, reducing the time spent traveling for water management and resulting in a significant reduction in water management efforts.

(2) Water and electricity saving effects

By accurately grasping the end-user water demand using ICT, it is possible to supply the right amount of water at the right time, which is expected to have a water and electricity saving effect at the pumping station. At the pumping station, not only can soft measures such as reviewing the water distribution period, reducing ineffective water supply, and reviewing the set water levels of the regulating pond and farm pond be reflected, but hard measures such as installing inverters can also be considered.

(3) Facility preservation effects

Optimal water distribution control is expected to reduce excess pressure and the load on deteriorated areas due to aging. In addition, by introducing various alarm functions to irrigation facilities, it will be possible to prevent malfunctions and accidents that are often overlooked in daily management.

(4) Accumulation of data for facility repair and renewal

In order to meet new local needs and adapt to agricultural operations, it is necessary to record the actual water usage and grasp the current situation, but water distribution facilities are mainly managed manually, and the actual situation is often dependent on the experience of the manager. By accumulating data using ICT and turning it into big data, it is expected that the current management situation will be grasped and problems will be identified.

(5) Rationalization of field water management

By having the water distribution facility supply water to the fields as well as distribute it all at once, it becomes unnecessary to install automatic water taps in each field, and it becomes possible to perform automatic water management at low cost. It also becomes possible to perform fertilization by pouring water all at once from the water distribution facility.

Important points to consider when introducing Distribution-WMS

- When introducing Distribution-WMS, it is necessary to thoroughly consider with farmers, WUAs, etc. the management form of the facility, the effects of introducing the system, and the management system after the introduction.

When introducing Distribution-WMS, it is necessary to thoroughly listen to the management methods and problems of the administrator who has been in charge of management, and to give ample consideration to the optimum level of control equipment for the irrigation facility in question, taking into account economic aspects such as life cycle costs, future management systems, and local opinions. In order to achieve a harmonious facility function as a whole system from the main facility to the terminal facility, the following points should be taken into consideration:

- Harmonization of management standards for main and terminal facilities
- Unification of information transmission systems that can grasp water demand and water distribution conditions in fields in terms of time and quantity
- Setting of specific time and quantitative management goals
- Setting of priorities for facilities that should be managed with emphasis and other facilities
- Management practices and methods for checking them
- Planning that takes into account personnel composition and costs for water management

Facilities to be applied for Distribution-WMS

- There are various types of water management for water distribution facilities, so it is necessary to select the most effective control method, control points, and monitoring points.

Water distribution facilities come in various forms, and it is necessary to consider how to maximize the function of each facility, and how to compensate for the decline in the function of existing facilities by using a system. The main forms of water distribution facilities are as follows:

(1) Water tank type: ON/OFF control or number of unit control

Example: Open canal - Regulating reservoir - Pump station (distribution tank) - Pipeline

This is the most common water distribution method using a pump station, and has the following characteristics:

- Mostly supply-driven
- High installation and construction costs for elevated water tanks
- Location is limited
- Targets large-scale rice field pipelines
- Demand-driven if adjustment capacity is sufficient

If the distribution tank has sufficient regulating capacity, demand-driven operation becomes possible through constant tank water level control. In order to set the required head at the very end of the canal from the elevated tank, it is necessary to reduce the pressure using a pressure reducing valve for the water distribution immediately below the tank. By introducing Distribution-WMS, even in the case of a surplus water type distribution tank where the regulating capacity of the tank is insufficient, real-time monitoring of the tank water level and inverter control of the pump station will enable operation according to the amount of water used at the terminal (Figure 2.10).

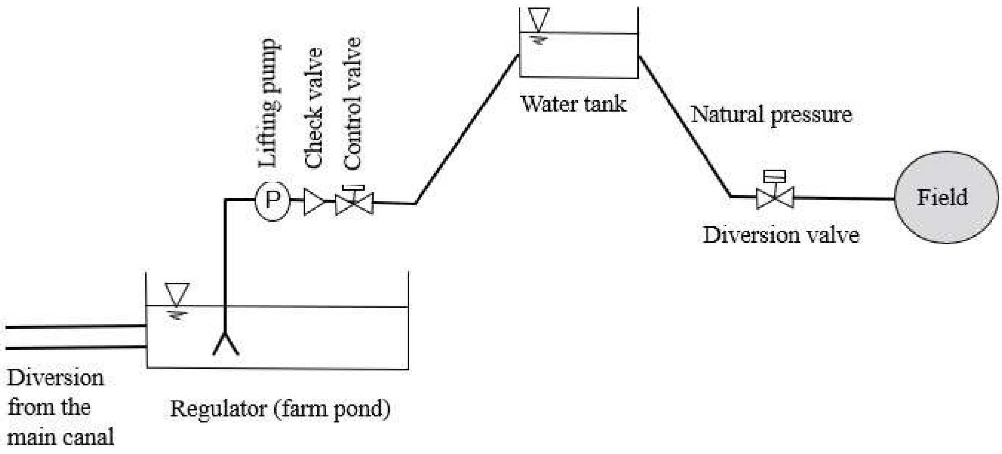


Figure 2.10 Water tank type: ON/OFF control or number of unit control (NIRE. 2019)

(2) Direct delivery pump type (without pressure tank): ON/OFF control or number of unit control

Example) Repeated water use canal - Pump station (direct delivery) - Pipeline

This is a common form for small to medium-sized paddy field pipelines, and has the following characteristics:

- No additional facilities required, low construction costs
- Supply-driven systems for small to medium-sized paddy field pipelines, though having high electricity costs

Since this is a direct-delivery system, when using ON/OFF operation, the power consumption does not change even if the end-use situation changes, resulting in higher electricity cost. By introducing Distribution-WMS, it becomes possible to distribute water according to water usage by monitoring the status of automatic water taps in real time and by introducing inverters to constantly control the estimated end pressure, resulting in water and electricity savings (Figure 2.11).

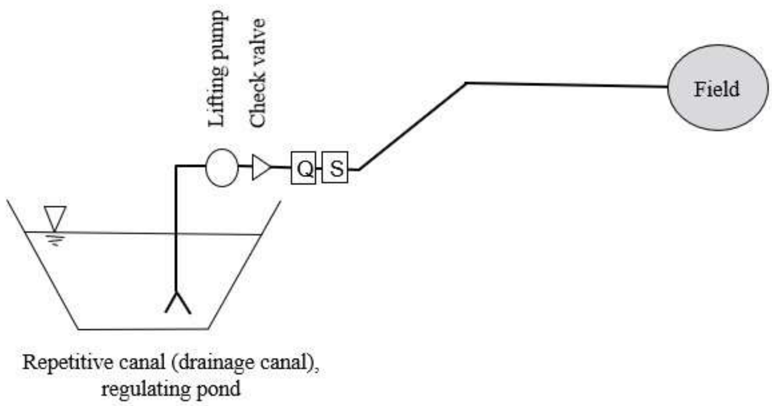


Figure 2.11 Direct delivery pump type (without pressure tank): ON/OFF control or number of unit control (NIRE. 2019)

(3) Direct delivery pump type (with pressure tank): ON/OFF control or number of unit control

Example: Open canal - Regulating pond - Pump station (pressure tank) - Pipeline

Used in relatively small capacity pump stations on flat land, it has the following features:

- Common in upland irrigation facilities
- Demand-driven
- Relatively small capacity irrigation facilities on flat land

When paddy and upland fields are mixed, the pump has to be turned on and off frequently during peak water demand, which places a heavy load on the pump. It is necessary to take measures such as switching to inverter operation during peak demand. The introduction of Distribution-WMS makes it possible to remotely monitor the operation status of pump stations and farm ponds, send various alarms, and remotely control the stopping and restarting of pumps in the event of a malfunction (Figure 2.12).

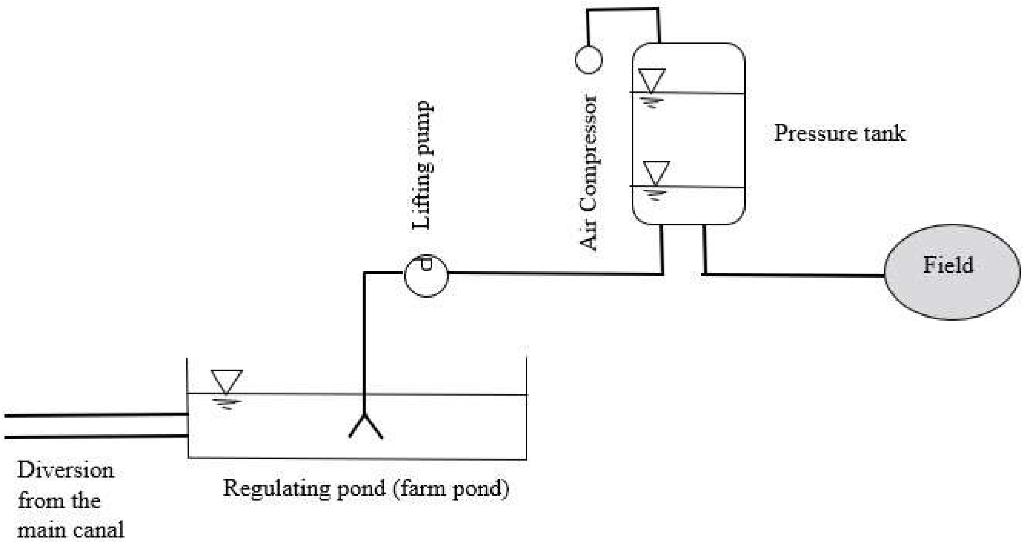


Figure 2.12 Direct delivery pump type (with pressure tank): ON/OFF control or number of unit control (NIRE. 2019)

(4) Natural pressure type

Example: Main open canal - Water tank - Pipeline

This type of water distribution system does not use pumps, but instead utilizes the difference in head in the canal, distributing water entirely by natural pressure. Demand-driven water distribution is possible by using floats and flow rate sensors in the water tank. It is necessary to link with the control by the check gate of the main canal (Figure 2.13).

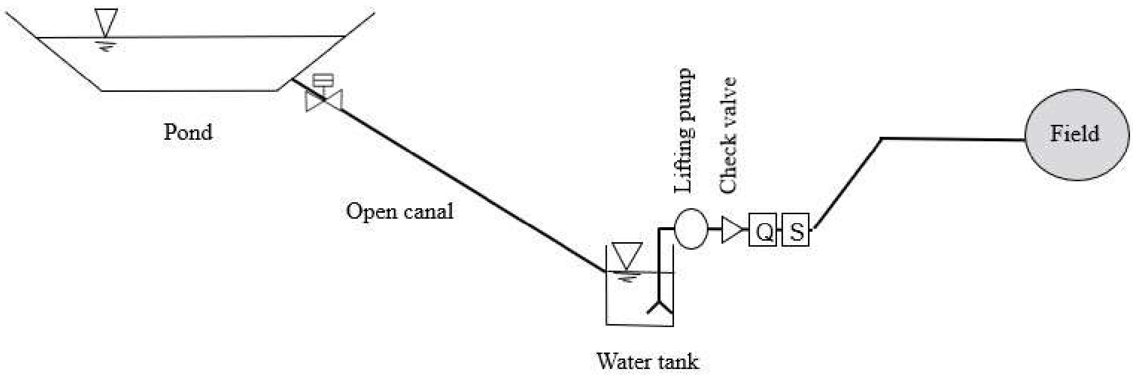


Figure 2.13 Natural pressure type (NIRE. 2019)

(5) Direct delivery pump type (without pressure tank): ON/OFF control or number of unit control

Example) Pond - Open canal - Pump station (direct delivery) – Pipeline

- Pond is used as a small-scale water source
- Pond water management is linked to water distribution management
- Water intake from pond needs to be adjusted during droughts

This is a method of conveying water from a pond (reservoir) to a pump station through an open canal and distributing it. It is necessary to manage the intake of water from the pond, which serves as the water source. Pump stations often use a direct-delivery system. By introducing Distribution-WMS, it is possible to link the water taps in the fields, the pump station that distributes water, and the pond facilities that serve as the intake source, which enables water saving at the pond, labor-saving, reductions in water usage, and electricity saving (Figure 2.14).

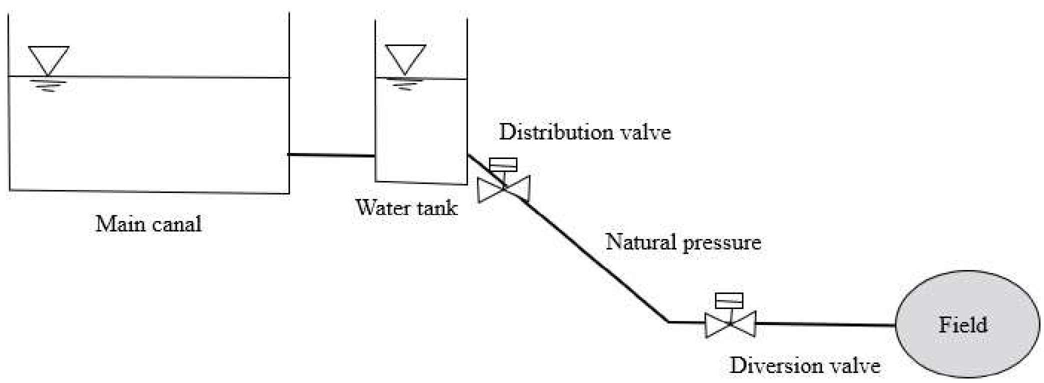


Figure 2.14 Direct delivery pump type (without pressure tank): ON/OFF control or number of unit control (NIRE. 2019)

2.4 Field Water Management System (Field-WMS)

Definition of Field-WMS

- Field-WMS is a system that can remotely and automatically control the water inlet or drainage outlet of a paddy field by installing a control device with Internet communication and sensing functions at the water inlet or drainage outlet.

(1) Existing water supply and drainage technologies for paddy fields

In order to reduce the labor required for water management in paddy fields, automatic water valves (autovalves) have been developed and sold, but most of them only have the function of maintaining the set water level, and cannot adjust the water level, control it remotely, or monitor the water level. Conventional automatic water valves have a mechanism that measures the water level of the paddy field with a float and controls the water supply by opening and closing the water pipe connected to the discharge part. Starting and stopping water supply, adjusting the water level, checking the water level, etc. basically required going to each field, and it took a lot of time just to manage the water supply of multiple paddy fields in remote locations.

There is no conventional technology for remote or automatic control of paddy field drainage. In developed paddy fields, the drainage outlet (water outlet) often inserts and removes a weir plate into a concrete manhole to fill and drain the water. In undeveloped paddy fields, there are cases where only PVC pipes are installed. It is necessary to go to each drainage outlet to take appropriate measures during drainage work and rainfall. Also, since there is no connection to the water supply valve, free flowing irrigation may occur in some cases.

(2) Basic definition of Field-WMS

To significantly reduce the water management work for paddy fields, it is necessary to operate the water supply and drainage and control the water level without going to the fields. Therefore, a system was developed that can remotely and automatically control both the water supply and drainage outlets of paddy fields by adding control devices with Internet communication and sensing functions to the water supply and drainage inlets of the fields.

Manually operated water taps are inexpensive and widely available, so it is necessary to keep the cost of the developed device as low as possible. Also, there are many manual water taps installed, and it is not realistic to replace them completely. A device was developed that can control water supply and drainage with the same specifications and can be attached to existing water taps.

Configuration of Field-WMS

- Field-WMS is composed of a control device with a communication function that can operate the water inlet or drainage outlet, a server that can record the field condition and send control commands, and software that can be operated on a mobile information terminal.

The main components of the Field-WMS (Kubota, WATARAS) are as follows (Figures 2.15-2.16):

(1) Control device

The control device is the same for both the water supply side and the drainage side. The motor is driven by power supplied from the solar panel, and the opening and closing of the water supply tap and the height of the drainage outlet can be adjusted in conjunction. In addition, the water supply side is equipped with water level and water temperature sensors, which serve as the basis for monitoring the situation in the paddy field or for determining when to start and stop water supply.

(2) Base station

It is possible to communicate with up to 60 control devices within a 500 m radius via low-power wireless communication.

(3) Server

The server records data such as water level, water temperature, water supply valve opening, and drain height for each paddy field, and also stores automatic water management control software and inter-field linkage software. It transmits directions for remote operation of the control device by control commands from the information terminal. It also operates the stored software to perform automatic control.

(4) Mobile information terminal (user interface)

The system is designed to be intuitive for farmers who do not normally use PCs or smartphones, with illustrations showing the status and allowing users to achieve their purposes with fewer operations.

(5) Control software

The software that controls the Field-WMS can check the data acquired by the water level and water temperature sensors, as well as weather information released by the Japan Meteorological Agency. It can also send instructions on starting and stopping water supply, forcibly draining water, and other necessary instructions on controlling the water depth.

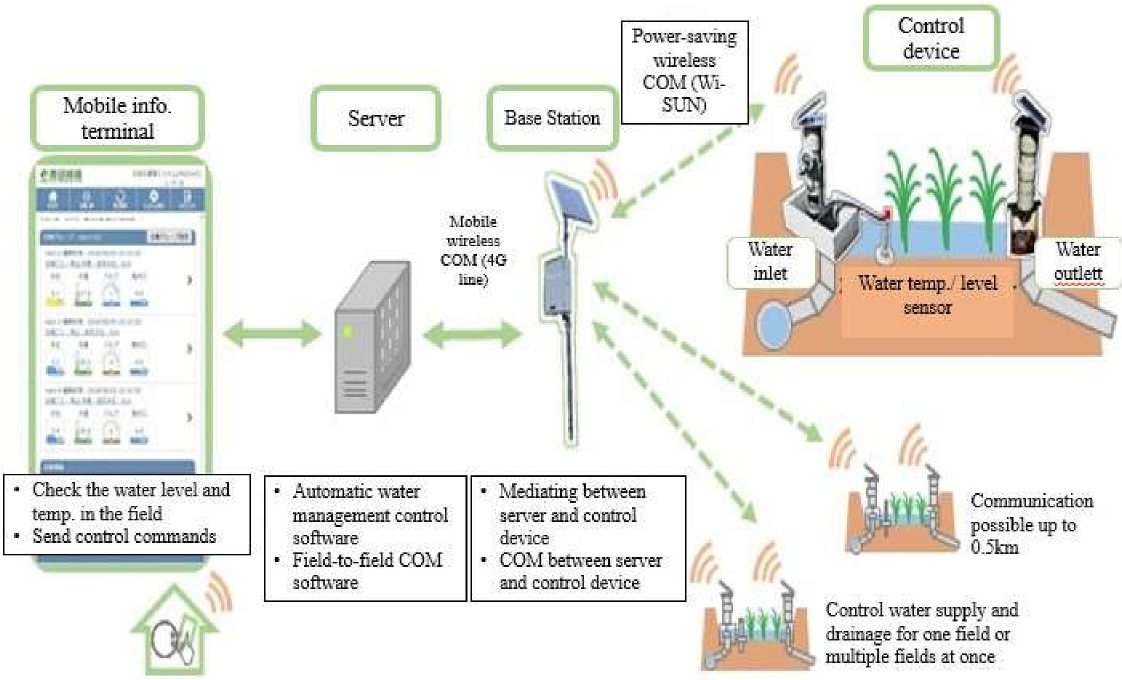


Figure 2.15 Overview of Field-WMS (NIRE. 2019)

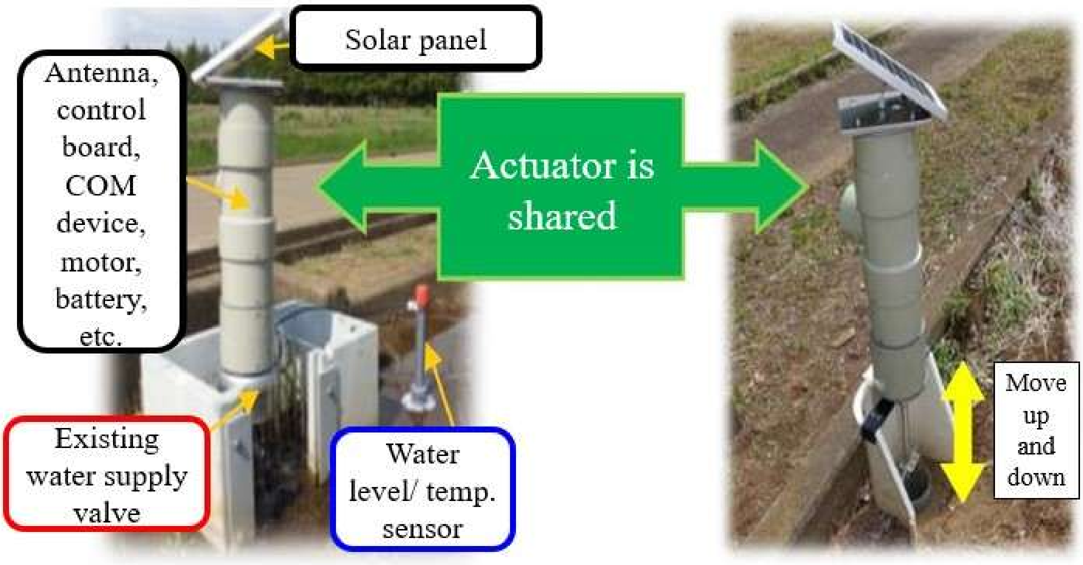


Figure 2.16 Control device installed on a water tap (left) and a control device installed on a drain (right) (NIRE. 2019)

Functions of Field-WMS

- Field-WMS has many functions to meet the various water management needs of farmers, local conditions, and unforeseen circumstances. Therefore, it is important to fully understand the functions and use it appropriately.

The main functions of the Field-WMS are as follows:

(1) Data display and viewing

Displays data and graphs of control information such as the open/close status of multiple sensors placed in paddy fields and water taps.

(2) Remote control

The water tap and the water outlet can be remotely controlled in real time. The opening degree of the water tap and the height of the outlet can be set.

(3) Automatic control

There are multiple water management methods to choose from, and they can be controlled automatically. The main water management methods are as follows:

Constant flooding

This function repeatedly starts and stops water supply to maintain a preset flood depth. To prevent frequent activation and deactivation due to slight changes in water level, the allowable reduction in flood depth can be set as desired. It is also possible to set the water outlet at a position higher than the preset flood depth to prevent overflow from the outlet. The height can also be set as desired.

Intermittent irrigation

Intermittent irrigation is a water management method in which water supply is stopped for a few days after flooding, and then water is supplied again when the flooding has disappeared to restore the current state. The Field-WMS has the function of reproducing intermittent irrigation. When the "set water level" and "intermittent irrigation cycle" are entered, water supply begins, and when the set flooding depth is reached, water supply is stopped until the number of days set in the intermittent irrigation cycle has passed. If the flooding depth is below the set depth after the set number of days has passed, water is supplied, and if it is above the set depth, water is again stopped for the number of days in the intermittent irrigation cycle.

Timed irrigation

In areas where the time periods for watering a field are limited, or to prevent a decline in yield or quality, like by taking measures against cold damage, it is possible to set the time periods for watering as desired. By inputting the start and end times of watering, it is possible to limit the time periods for watering when using the above-mentioned constant flooding or intermittent irrigation.

(4) View weather data and precipitation forecasts

By setting a nearby weather observation point in advance, the user can view weather data. The user can also view precipitation forecasts published on the Japan Meteorological Agency's website.

(5) Alarm notice

An alarm notice (email) will be sent if there is an abnormality in the equipment or if the actual water level differs from the set level. The same applies if the water temperature is higher or lower than the expected water temperature. Furthermore, by linking with weather forecasts, an alarm notice will be sent if abnormal weather such as a typhoon is predicted.

(6) Linkage between paddy fields

When there are a large number of plots to be managed, it takes a lot of work to set up each plot, so multiple plots with the same cropping system can be grouped together, and the same water management can be applied within the group.

(7) Preparation of daily reports

Water level, water temperature, and water management data (water tap opening, water outlet height, set water level, control command) can be output as daily reports.

(8) Measurement of reduced water depth

It is possible to measure the reduced water depth based on water level data and water supply and drainage conditions.

Effects of introducing Field-WMS

- The introduction of Field-WMS will enable a significant reduction in the time spent on water management. It is also expected that the yield and quality of rice will be maintained while labor-saving water management can be performed according to weather and local conditions.

The main effects of introducing Field-WMS are as follows:

(1) Reduction in water management effort

By introducing Field-WMS, it becomes possible to remotely and automatically control the water taps and drains. This makes it possible to minimize visits to the paddy fields, reducing the time spent traveling for water management, and leading to a significant reduction in the labor required for water management.

(2) Effects on yield and quality

There are cases where the introduction of Field-WMS has led to more precise water management than ever before, resulting in increased yields. There are also cases where the water management effort required for rice cultivation has been significantly reduced while maintaining the same yield as before. In this way, the introduction of Field-WMS has the effect of contributing to the maintenance and improvement of yield quality while relatively reducing the water management effort required for rice cultivation.

Expanding the functionality of Field-WMS

- Field-WMS is being developed with functions that allow it to link with external data and programs to achieve optimal water management. When introducing Field-WMS, it is necessary to obtain and consider the latest information on the development stage.

Field-WMS is being developed with functions to realize optimal water management according to weather conditions and crop growth by linking with external data and programs via API. In addition, by providing sensing and water management data obtained by the Field-WMS to external content, it can also become part of a system that supports agricultural management across multiple fields and a water management system that links fields with a wide area. Furthermore, by linking with soil moisture sensing data, water management can also be performed when FOEAS (Farm-Oriented Enhanced Aquatic System) fields are used as converted fields.

The following functions are currently being developed:

(1) Development of weather-responsive water management software

Weather-responsive water management software has been developed that uses mesh agricultural weather data and growth prediction models to optimize and automate field water management. This software can easily and automatically create water management schedules according to region, variety, and crop season, automatically adjust schedules appropriately based on growth predictions, and automatically calculate optimal irrigation times to raise (or lower) water temperature. By introducing this software into a Field-WMS, it will be possible to achieve advanced water management in fields that was previously difficult to do manually.

(2) Remote control of water management when using FOEAS field as converted from a paddy field

When introducing a Field-WMS into a FOEAS field and using it for sub-irrigation operations when using converted fields, decisions on irrigation operations are important. For this reason, a system has been established in which the soil moisture condition in the plowed soil layer is monitored by the Field-WMS and irrigation is performed remotely. To monitor the soil moisture condition in the plowed soil layer, the Field-WMS has been equipped with a function to install a soil moisture sensor and a function to obtain the amount of rainfall and evaporation from an external weather database (crop weather database and mesh agricultural weather data) and calculate the soil moisture amount in the plowed soil layer.

(3) Linking with external content via API

Linkage with Distribution-WMS

The latest water management systems are being constructed to provide an efficient and stable supply of water resources by linking with systems that control main canals and pumps. Water demand at the field level can be predicted based on the reduced water depth and water management schedule measured by the Field-WMS, and precipitation forecasts based on mesh agricultural weather data. By controlling irrigation facilities based on these data, appropriate water distribution and energy conservation are possible.

Linkage with agricultural management support systems (multi-fields agricultural management systems)

The multi-field agricultural management system is a system that manages planting and cultivation management conditions based on field maps. There is a plan to link the Field-WMS and the multi-field agricultural management system via API. Using water levels, water temperature, and water management data measured by the Field-WMS, it will be possible to visually manage a series of flows with other agricultural work on a field map. It is also aimed at creating a cultivation plan in the multi-field agricultural management system and automatically managing water accordingly.

【Reference】Integrated display of various ICT data using API

A system that integrates and displays various types of ICT data was developed in Thailand and Vietnam. In Vietnam, the system integrated ICT data from two Japanese manufacturers, while in Thailand, data from ICT equipment installed by the Royal Irrigation Department (RID) and the Eastern Water Resources Development Public Company (East Water) was also integrated. In particular, in Thailand, ICT data from rain gauges, pipeline flow meters, pressure gauges, and other equipment introduced in the Project for Irrigation toward Smart (PIS), the first model irrigation project implemented in the country, was integrated into a display system that can cover the entire area of No. 9 Regional Irrigation Office (RIO9), which has jurisdiction over eight provinces in eastern Thailand (Figure 2.17).

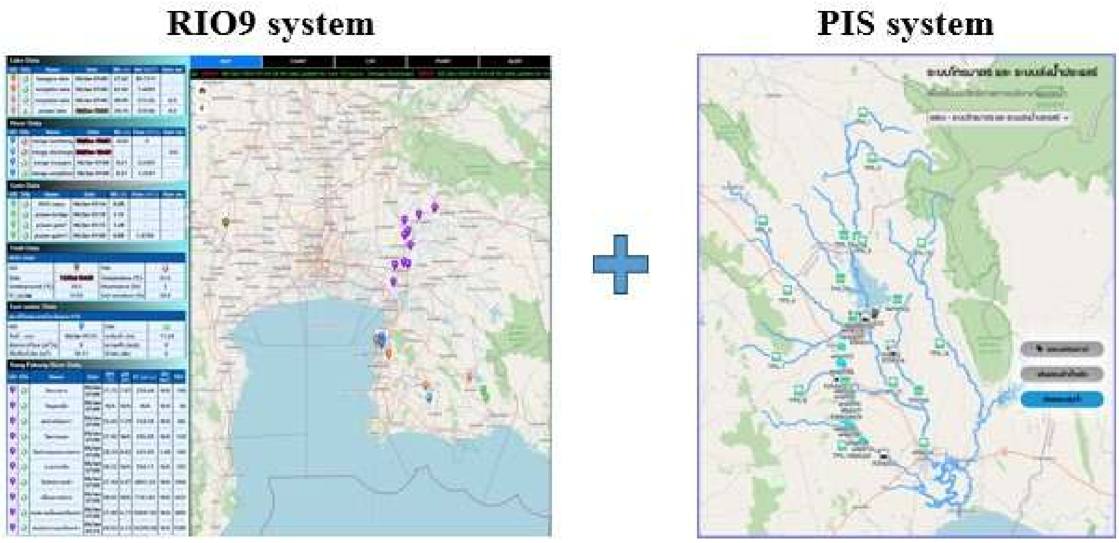


Figure 2.17 Image of integrated display of RIO9 system and PIS system in Eastern Thailand

3. Basics for Introducing ICT Water Management

Basic matters

- In introducing ICT water management, here is clarified the purpose, effects, and basic points, including main facilities and end-user facilities.

The basic points to consider when introducing ICT water management are as follows:

- When introducing ICT into a district's water management system, as the conditions (irrigation facilities, water management organizations, water use order, etc.) differ from district to district, issues such as inequitable distribution of agricultural water, occurrence of ineffective discharge, burden of maintenance and management work, etc. must be identified, and then it must be confirmed in advance whether the introduction of ICT water management is effective as a measure to resolve these issues.

- With the introduction of ICT, it is possible to link, for example, the remote monitoring and control of pump stations and diversion gates (main canal level) with multi-function automatic water taps installed in fields (terminal level). In order to link the facilities effectively, the upstream facilities need to grasp the exact water demand in the target terminal beneficiary area and distribute water accordingly, so the terminal level needs to provide appropriate feedback on the demand volume to the upstream level. Furthermore, the introduction of ICT makes it possible to transmit and distribute water according to terminal water demand, but if this causes the peak water intake volume to change, it will be necessary to consider adjusting the water supply volume of the main canal and devising facilities to reduce ineffective discharge.

- ICT equipment is sold by a variety of manufacturers, and system development and specifications are not standardized for each manufacturer, resulting in a large number of incompatible systems. When using multiple incompatible systems within the same area, it is necessary to check separate screens for each system, which takes time. When introducing ICT, it is desirable for managers and farmers to make adjustments and introduce equipment that is as compatible as possible. Furthermore, if farmers are unfamiliar with operating the equipment, the full effect of introducing ICT may not be realized. Therefore, it is necessary to consider establishing a support system to help farmers become familiar with operation and to create a system that is easy to operate by improving the user interface, etc.。

- When installing ICT devices, it is necessary to pay attention to the installation location. In order to ensure a good communication environment, check the installation location in advance. In addition, if the equipment is powered by solar energy and batteries, pay attention to sunlight and weather. Also, ensure that the installation location does not interfere with the farm work of farmers.

- ICT equipment is generally expensive, so it may be difficult from a financial standpoint to install it in all facilities in a district. The effective scope of introduction for the district should be considered. In order to transmit and distribute water according to demand from the water source to the terminal fields, even if there are facilities that are operated manually, the effectiveness of ICT introduction can be realized if efficient water management according to demand can be carried out by partially introducing ICT.

- By linking data between main facilities, water distribution facilities, and end-user facilities, efficient water transmission and distribution and the timely and appropriate supply of water to fields can be achieved at the same time. However, careful consideration must be given to whether an ideal system based on such data linkage would be over-specified for the current issues. When considering the scope of ICT implementation, it is necessary to take into account the importance of the facility, future management system, local intentions, etc., while also paying attention to compatibility of systems between facilities, harmonization of management standards, and ensuring security, while also considering economic efficiency.

- In addition to promoting the introduction of ICT in plain areas where the communication environment is easily developed, it also should be considered introducing ICT in hilly areas by coordinating with the development of communication infrastructure in rural areas.

- In order to fully realize the benefits of introducing ICT, users themselves must properly maintain and manage their ICT equipment.

Points to check when introducing ICT

- When introducing ICT, first identify the issues facing the area and then clarify the purpose of introduction and the expected results.

(1) Understanding and organizing the issues

Issues to be addressed after the introduction of ICT equipment include securing a budget for ongoing maintenance such as communications and part replacement, assigning managers who are familiar with how to operate the equipment, and establishing a management system for the entire irrigation system. In advance of introducing ICT, it is necessary to confirm whether the district is prepared to introduce ICT, including the items shown as follows:

- Is there a sufficient budget?
- Are there insufficient ICT implementation experiences and are there attempts to implement quickly?
- Are the operators familiar with maintaining and operating the equipment? Does the project implementor have sufficient budget for long-term operator training?
- Are there excessive expectations for large water savings or ease of operation?
- Are managers eager to use low-cost equipment without considering performance or necessity?
- Are there clearly defined operational objectives?
- Are actual people who will maintain the new system involved from the planning stage?
- Do the designers have experience designing irrigation systems?

(2) Purpose and effects of ICT introduction

The main purposes and effects of introducing ICT are as follows:

Reducing water management effort

By using ICT to automate and remotely operate water distribution facilities such as pump stations and diversion gates, as well as field water taps, it is possible to reduce the amount of travel required for water management, such as facility monitoring by WUAs and field patrols by farmers, thereby significantly reducing the amount of water management work. This effect has been widely demonstrated, and is often thought to be a motivation for the introduction of such systems.

Water and electricity saving effect

ICT can accurately grasp end-user water demand and supply the right amount of water at the right time, reducing ineffective discharges and eliminating imbalances between water distribution blocks. Pump stations can also expect to save water and electricity by reviewing water distribution periods and reducing ineffective water transfer. The water-saving effects of reducing ineffective discharges and achieving accurate water distribution management have been demonstrated in several sites. Meanwhile, the power-saving effects may vary depending on the water management method and the facility layout within the area.

Improving the efficiency of response operations in the event of an accident or disaster

Remote monitoring of facilities such as water pumps using ICT will enable WUAs and other organizations to respond quickly when breakdowns occur. It will also enable remote operation of drainage pumps during heavy rains and floods, helping to prevent accidents for managers. These effects have been demonstrated in several sites.

Improved yield and quality

ICT enables more precise water management than ever before, and is expected to contribute to maintaining and improving crop yields and quality. This effect has been demonstrated in several sites.

Technical issues

- In Field-WMS, technical issues need to be resolved, such as the scope of installation of ICT equipment, the installation of adjustment facilities for water management systems at the branch canal level, system compatibility, and the difference between pipelines and open canals.

(1) Scope of ICT equipment installation

In order to effectively link ICT-based water distribution facilities (pump stations, diversion gates, etc.) with Field-WMS, it is necessary to consider installing automatic water taps in all fields within the water supply range of the water distribution facilities and appropriately feeding back all water demand within the block to the water distribution facilities. If automatic water taps are installed only in some fields and the remaining fields have to take water manually, the pump station will not be able to supply water based on the amount of water demand, and appropriate water distribution to the entire block will not be possible.

(2) Establishment of regulation facilities

By automating the control of water distribution facilities (pump stations, diversion gates, etc.) using ICT, it becomes possible to supply water according to the water demand of end-use fields, and it is expected that the amount of water diverted will be greater than before during peak water demand in each block. If the amount of water supplied to the main canal from the water source is not linked to the end-use water demand, when the amount of water diverted by the upstream water distribution facility increases in line with peak water demand, there is a possibility that downstream water distribution facilities will not be able to divert the required amount of water. In order to mitigate the impact on the downstream side, it is important to make effective use of existing regulating facilities, as well as to devise measures such as dispersing peak water demand by adjusting water intake rules and using ICT to rotate water use more efficient. In addition, making the water outlet in a field an automatic one is also considered to be effective in suppressing the occurrence of ineffective discharges and mitigating the impact on the downstream side.

(3) System Compatibility

The standards and specifications of ICT equipment systems are not necessarily uniform among manufacturers, and when incompatible systems coexist in the same area, it becomes necessary to check separate screens for each system, which is inconvenient for both managers and farmers. In addition, the following problems arise:

- Lack of compatibility between systems makes it difficult to consolidate data.
- When farmers use water taps or other equipment with incompatible systems, water management operations become complicated.
- When switching to water taps or other equipment with a different system, data accumulated in the old system may not be able to be transferred to the new system.

When introducing ICT equipment, it is advisable for managers and farmers to clarify the purpose of the ICT introduction, carefully consider the necessary equipment in advance, and create a system that ensures compatibility as much as possible.

(4) Installation of automatic water taps in open canals

When installing a multi-function automatic water tap in an open canal, there may be periods when water cannot be supplied to the field due to insufficient flow rate in the canal as shown in Figure 3.1. It is necessary to provide appropriate feedback on the water demand of the terminal field to the manager of the water distribution facility, etc., to ensure the amount of water supply required to operate the multi-function automatic water tap.

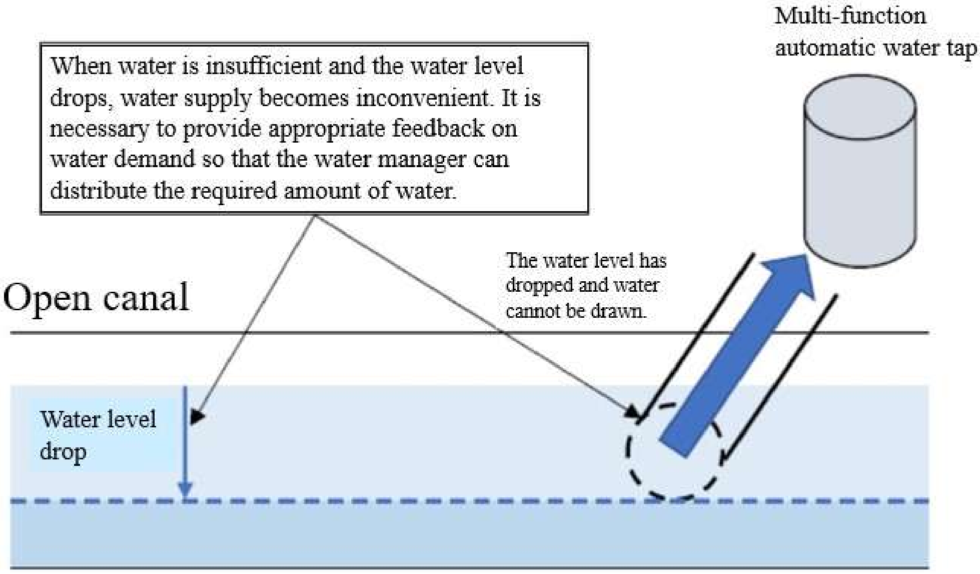


Figure 3.1 Water supply problems due to insufficient water levels (image)
(Ministry of Agriculture, Forestry and Fisheries. 2023)

Location and installation conditions

- When introducing ICT equipment, it is necessary to check the terrain and the existing communication environment to ensure that a good communication is secured. It is also necessary to confirm that the maintenance of the equipment can be carried out without any problems.

(1) Ensuring a communication environment

There have been cases where multi-function automatic water taps were installed in the shadows of mountains or during periods of bad weather, and solar power generation was not possible, causing battery voltage to drop, making it necessary to charge the device or change the settings of the device, or where the communications environment at the location was unstable, making installation difficult.

When introducing ICT, it is necessary to understand in advance the installation and usage status of communication equipment and servers. Also it is necessary to draw up an introduction plan that will create a good communications environment between ICT equipment (control devices), communications equipment, servers, and mobile information terminals. Communications equipment should be planned to be installed in a position where communication is possible from multiple control devices, and the communications environment can be improved by installing it as high as possible. When installing communications equipment at the same height as ICT equipment (control devices), care must be taken to ensure that the height is higher than the one of the crops.

(2) Ease of maintenance

From the demonstration cases, issues have been raised regarding the maintenance and management of ICT equipment, such as the installation locations of water level and temperature sensors, the inflow of garbage and clogging, and damage caused by being bitten by living creatures. Examples of these issues are shown below.

- Location of water level and temperature sensors

  - Because they are installed within the field, they can become an obstacle for agricultural machinery.
  - The terminal water tap is large, making it difficult to mow the grass.
  - The water level sensor gets buried in mud, so measures such as digging around it are necessary to prevent soil accumulation.
  - Because waves may prevent accurate water level measurement, it is effective to install corrugated sheets to protect the water level sensor and a protective manhole (with holes or slits) to store the water level gauge.
  - With water level sensors (pressure type), soil particles could adhere to the sensor, causing abnormal values, and in the event of an error, the sensor had to be cleaned (currently, abnormal values no longer occur by installing a protective tube, which has led to reduced labor).
  - Bird droppings soiled the solar panels, reducing output.

- Inflow and clogging of garbage

  - Because it was used in an open canal, problems such as clogging due to floating grass and sediment occurred. This was likely to cause breakdowns, and inspections to remove debris were also burdensome.
  - Breakdowns occurred due to sediment entering the open canal during heavy rains.

- Damage caused by being bitten by living creatures

  - Ants entered the sensor, built a nest, and caused abnormal values.
  - The cord of a multi-function automatic water tap was cut due to damage caused by mice.

In order to fully realize the benefits of introducing ICT, it is necessary to install and maintain ICT equipment while keeping these issues in mind.

4. Introduction of ICT water management technology

4.1 Selection of ITC water management technology

Domestic Survey

- When expanding ICT water management technology overseas, the project promoter will collect information on ICT water management technology that has been introduced in irrigation projects in Japan.
- Progress is being made with the development of ICT water management equipment that utilizes mobile phone networks, cloud services, the Internet, smartphones, etc., making it cheaper, easier to use, and more convenient for users.
- When expanding Japanese-made ICT equipment to overseas markets, it is necessary to select ICT technologies and equipment that can be introduced in the host country, taking into account the circumstances of the host country.

(1) Collecting information on irrigation water management both domestically and internationally

- Collect information on projects related to updating water management systems for national irrigation projects in Japan.
- The Ministry of Agriculture, Forestry and Fisheries is conducting a demonstration study of smart agriculture using ICT technology. In addition, ICT technology related to disaster prevention for reservoirs and other facilities is advancing.
- The Ministry of Land, Infrastructure, Transport and Tourism is conducting an Innovative River Technology Project and other projects, which have demonstrated the possibility of using crisis management water level gauges and simple flow measurement technology in the irrigation field. Note that the Innovative River Technology Project is premised on the use of cloud computing.
- When Japanese-made ICT equipment is deployed overseas, it often becomes an international competition, so collect information on ICT equipment being developed in Europe, the United States, and East Asia.

(2) Selection of domestic ICT water management technologies

- Assume the ICT water management technology required by the host country from reports on irrigation projects prepared by the Japan International Cooperation Agency (JICA) and international development financial institutions (World Bank, Asian Development Bank, etc.).
- For domestic manufacturers of ICT water management technology, create a comparison table by function using the manufacturer's websites and latest catalogs.
- Obtain as much information as possible about each manufacturer's equipment prices, installation costs, maintenance costs, monthly service fees, etc.
- When evaluating ICT water management technologies, keep the following in mind. In particular, in developing countries, the initial costs of ICT technology and operating costs over its useful life (life cycle costs) are important, and if the life cycle cost is high, the technology will not be adopted, no matter how beneficial its functions are.

- The equipment price for the TM (water level sensor, data transmission device) for water level measurement is less than 1 million yen.
- The annual operating costs (communication costs, server usage fees, service fees, etc.) are low.
- The equipment has a proven useful life of more than 5 years.
- Wireless transmission.
- It operates on an independent power source.
- The data transmission frequency is variable, and it is possible to convert water level to flow rate and set alarm thresholds.
- The equipment is easy to install and maintain.
- Spare parts other than the main parts can be procured locally.
- The system can be installed on the physical server of the relevant organization in the host country (check whether there is a countermeasure in case this is not possible).
- The system can be displayed in sync with the existing ICT equipment owned by the host country (check whether there is a countermeasure in case this is not possible).
- The data can be viewed on a smartphone.

- When using cloud services, get information on the prices and service levels of international or Japanese cloud companies. In developing countries, international cloud companies have an advantage in terms of usage fees and services. The main international cloud companies are as follows:

  - Microsoft (Azure)
  - Amazon (AWS)
  - Salesforce (Sales Cloud)
  - IBM (IBM Cloud)
  - SAP (SAP Cloud Platform)

- The main Japanese cloud companies are as follows (excluding Japanese branches and joint ventures of international cloud companies):

  - NTT Data
  - Fujitsu
  - NEC
  - Internet Initiative

(3) Management of ICT water management equipment

- When the ICT water management equipment to be adopted is decided, prepare a list of the equipment model numbers, etc. as soon as possible. This will be used as a reference when the equipment is finally handed over to the host country.

Introduction of ICT equipment

- In developing countries, TM equipment, which is the basis of Main-WMS, may not be fully operational, so TM is often requested as a priority ICT technology.
- The basis of the TM system is to transmit data from water level sensors and other devices to a cloud server via a mobile phone network, and users can access the TM data from their smartphones or other devices via the Internet.
- The server to which TM sensor data is transmitted is either a server of a cloud company in the host country, or a physical server owned by the host country's ICT water management organization.
- Consider in advance how to respond if a request is made to synchronize the display of the existing TM system owned by the ICT water management organization and the newly installed TM.
- When signing a contract with an international cloud company, data transmission to a server overseas may not be permitted due to the host country's domestic rules. In such cases, if the host country's relevant organizations can sign a contract with a cloud company themselves, the country in which the server is located may not be an issue.

(1) Basics of the TM system

- A TM system consists of sensors, transmission equipment, a server, and display software (database) for terminals. TM manufacturers either develop all of these in-house, introduce products from other specialist companies as part of their systems, or develop them jointly with other companies.
- In developing countries, mobile phone networks are relatively well developed, so people can make calls on their mobile phones and access the Internet with their smartphones, except in mountainous areas and other areas where signals are difficult to reach. The most reliable way to transmit sensor data to a server is via a mobile phone network.
- It is preferable to use a cloud server, which is advantageous in terms of price, maintenance, and security. If a physical server is used, not only will initial costs be incurred, but there will also be uninterruptible power supplies (UPS), air-conditioning rooms, maintenance costs by system engineers, renewal costs, etc., and security against viruses and hackers will be reduced. Users access the server from the Internet and obtain TM data from terminal devices such as PCs, smartphones, and tablets in a form organized and adjusted by the display software.

(2) Server in the host country

- In many developing countries, irrigation projects are implemented as national projects, so the data of TM installed in irrigation water management facilities is national data, and its transmission and processing outside the country may be restricted by domestic rules such as cyber security laws. Therefore, it is preferable that TM data be processed domestically by a cloud company in the host country or the ICT water management institution's own physical server.
- If a server already owned by the ICT water management institution is used, the server usage fee is free, but the security of the server is lower than that of the cloud, and maintenance of the server hardware and the update of operation system (OS) are required, so data processing and access to data via the Internet are likely to be unstable.

- If the server of the ICT water management institution is used, manuals must be prepared and practical training must be provided to the server administrator so that he or she can manage the OS of the newly installed TM.
- When demonstrating ICT technology in a model area, the server of a cloud company in the host country or an international one may be used, and after the smooth operation of the system is confirmed, the ICT system may be installed on the server of the ICT water management institution. Usually, international cloud companies are used because server usage fees are cheaper than domestic companies and their services and security are also more advanced. Ultimately, the ICT system is transferred from the international cloud company's server to the ICT water management institution's server, but to avoid accidents, it is necessary to proceed while checking the work procedures, such as backups, setting up multiple virtual servers, and disposing of unnecessary servers after the transfer.
- As long as services are provided via the Internet, they will inevitably be exposed to attacks such as unauthorized access. Since SSL encryption, which encrypts information, and the issuance of the certificate are charged, there are servers that do not have SSL. Servers in the host country that do not have SSL may be subject to damage such as hijacking, being used as a springboard, information leakage, and access interference. If it is necessary to install on such a server to comply with domestic regulations, it is necessary to take thorough defensive measures with the support of a server engineer to avoid affecting the system.

(3) Synchronization with existing TM systems

- In developing countries, dams, headworks, and other major irrigation facilities may already have TM equipment installed. If these TMs are functioning, they may be required to be synchronized with the newly installed TM and displayed simultaneously.
- In countries that introduced TM early on, various types of TM equipment produced in multiple countries with foreign aid, etc. are installed. In order to synchronize the data of these equipment with the new TM, minimum conditions must be set, such as TM data being stored as CSV files. TMs that do not meet the conditions are excluded from synchronization.
- Usually, older types of TMs do not meet the conditions, so existing TMs that can be synchronized are often limited to those that have been installed for 1 to 3 years.
- The useful life of TMs as measuring equipment is set at 5 years in the useful life table for depreciable assets, so it may be more economical to update existing equipment to coincide with the installation of new TM equipment than to try to synchronize it.

(4) Use of international cloud services

- In some cases, government agencies of host countries have contracted with international cloud companies to process data collected domestically on servers overseas. This is particularly common in countries with frequent power outages and problematic telecommunications conditions. In such cases, the government agency in question retains ownership of the server by contracting with the international cloud company. In other words, if an ICT company uses a server built by its government agency client, the project promoter can operate its water management system in the cloud of an international cloud company.
- At present, it is recognized that owning physical servers is wasteful and unstable, and cloud use is becoming mainstream. In this environment, using international cloud companies, which offer low prices, quality of service, and security, is considered a highly forward-thinking approach.

Introduction of the latest ICT water management system

- When introducing the latest water management system, the project promoter will first understand the current configuration of the water management system and the current state of water management corresponding to it. Then, the project promoter will understand the level of each technology stage toward the introduction of the latest water management system and decide the direction of development.

When introducing the latest water management system, it is necessary to categorize the current water management system and the level of the new water management system. An example of categorization of the deployment level corresponding to the latest water management system is shown in Table 4.1.。

Table 4.1 Deployment levels corresponding to latest water management systems (NIRE. 2019)

	Level 0	Level 1	Level 2	Level 3	Level 4
Overview	Current TM/TC	Development of Field-WMS	Development of Distribution-WMS	Data linking between Field-WMS and Distribution-WMS	Data linking from Field-WMS to Main-WMS
Main canal level (water supply system)	○	○	○	○	◎
Branch canal level (water distribution system)	×	×	○	◎	◎
Field level (terminal system)	×	○	○	◎	◎

Note) ○: Water management system in place, ×: System not in place, ◎: Data linking with each level possible

An overview of each deployment level is as follows:

(1) Current water management system (Level 0)

Water management systems are compatible with various irrigation scales, hierarchical structures, and irrigation forms, and are constructed to suit local water management. Here, it takes as an example a wide-area irrigation district consisting of main canals, branch canals, and terminals, and define the situation in which a main canal level TM/TC system managed by WUA is in place as Level 0.

(2) Introduction of Field-WMS (Level 1)

Field-WMS has been introduced in terminal fields, enabling automation of water taps and remote monitoring and control. At the field level, advanced water management is possible, including remote monitoring of flooding and growth conditions, and schedule management based on weather and growth data. However, there is no connection with higher-level water managers, so it is difficult to consider the water source situation and adjust water distribution times and amounts.

(3) Introduction of Distribution-WMS (Level 2)

Currently, most water is managed manually, and water management systems are the least developed. At the branch canal level, regulating facilities can automatically and remotely monitor and control water distribution according to the water usage situation in the fields and the amount of water sent from the main canal. However, there is no data link with the Main-WMS, making it difficult to allocate water appropriately on a wider scale.

(4) Data linking between Field-WMS and Distribution-WMS (Level 3)

By enabling data linking between fields and branch canals, it will be possible to distribute water appropriately at the branch canal level according to the irrigation schedule and demand at the end. It will also be possible for the field side to check the water distribution schedule of the regulator and farm pond at the branch canal level and adjust water distribution as necessary.

(5) Data linking from Field-WMS to Main-WMS (Level 4)

Data can be linked between fields and branch canals, or between branch canals and main canals. This allows the main canal system to grasp water management in fields through the branch canals, realizing consistent water management from fields to water sources. The latest water management systems aim to reach this level.

The operation of water sources, etc. is accurately reviewed, water supply time lags are eliminated, ineffective discharge is eliminated, and efficient water supply and distribution is realized. In fields, appropriate water supply according to crop growth is possible, and problems such as droughts and uneven water distribution at the regional level are also solved, making it possible to receive reliable water distribution.

Operability of ICT equipment

- Even if ICT equipment is introduced, there is a possibility that the full effect will not be realized if the users are unfamiliar with how to operate it. In the demonstration case, it was pointed out that when using a smartphone or other device for water management, there are cases where users are unfamiliar with how to operate the equipment and are reluctant to use it for farming, so it is necessary to consider a support system for using the control software.

One issue that has been raised as ICT adoption moves further in the future is that people who are unfamiliar with ICT equipment will have to acquire new devices such as smartphones, and will need to undergo training to become accustomed to using them. As an example, in one area, farmers initially operated water taps manually based on the rotation irrigation rules, but with the introduction of ICT (installation of multi-function automatic water taps), the rotation irrigation rules have been incorporated into automatic control. In this area, operations based on the rotation irrigation rules are carried out using smartphones, and the benefits of introducing ICT have been fully realized as farmers become familiar with the operations.

Economic efficiency

- When introducing ICT equipment, consider the initial costs, renewal costs, communication costs, and the effective scope of ICT introduction.

(1) Initial cost, renewal cost

From the demonstration cases, in addition to the high initial cost of introducing ICT for multifunctional automatic water taps and electrification of facilities, the high maintenance and management costs, including communication costs (replacement of parts such as UPS batteries for base stations and storage batteries for sub-stations, inspection of computers and communication devices, provider fees, etc.), often become a heavy burden for WUAs and farmers. In addition, for farmers who practice crop rotation, the construction costs for installing multifunctional automatic water taps increase because the fields where rice is planted change every year. When introducing ICT, it is necessary to thoroughly consider the effects of introduction such as reduction in patrol and operation labor and reduction in ineffective discharge, the management form of the facility, and the management system after introduction, together with farmers and WUAs. Rather than introducing an unnecessarily advanced system, it is necessary to consider the optimal level of ICT development based on the local situation, taking into full consideration the effects of ICT introduction, economic efficiency such as life cycle costs, future management system, and local intentions.

(2) Communications costs

By selecting an appropriate communications method according to local conditions, it is expected that the economic burden can be reduced. For communication routes that need to avoid failures due to lightning or unexpected line breaks, and for communication routes that send and receive relatively large volumes of data such as videos, it is necessary to use a carrier that has high communication stability and communication capacity and has well-established detour routes, but the communication costs are generally high. On the other hand, for communication routes used to collect daily information at the field level, the density of information sent and received is low and the risk of communication failure is small, so the economic burden can be reduced by independently establishing an inexpensive communications environment. It is important to select the optimal communications method for each communication route within the water management system by properly evaluating communication costs, communication capacity, risks of failures, and maintenance labor.

(3) Effective ICT Implementation Scope

<u>Scope of ICT implementation based on water management method</u>

The following trends were observed from the survey on the status of ICT adoption.

- In water management systems where the main canal level to the water distribution level is supply-driven or semi-demand-driven, and the end level is demand-driven, ICT has already been introduced in many areas, and even if without data linkage, it is expected that water distribution will improve and the labor of water management will be reduced. In addition, by introducing ICT to main facilities and water distribution facilities where TM/TC has not been introduced, and by introducing multi-function automatic water taps at the end, it is expected that water distribution will further improve and the labor of water management will be reduced.

- In water management systems where the entire canal is supply-driven or semi-demand-driven, ICT has already been introduced in areas, even if without data linkage. By introducing ICT to main facilities and water distribution facilities where TM/TC has not been introduced, and by introducing multi-function automatic water taps at the terminal, it is expected that water distribution will further improve and the labor of water management will be reduced.
- In the case of the demand-driven water management system for the entire canal, there are few problems with water use and water management, and the effect of introducing ICT in improving water distribution and reducing the labor of water management is not as great as that of the supply-driven system.

Installation range of multi-function automatic water tap

From the demonstration case, when considering the installation of multi-function automatic water taps, it is economical to install the number appropriate to the area to be supplied with water. Furthermore, if the aim is to reduce the labor required for work done during the day by introducing ICT equipment, it is necessary to install multi-function automatic water taps in most of the relatively large fields in order to achieve the effect. On the other hand, even if it is only possible to introduce them in some fields due to the cost of introduction, the labor-saving effect can be seen if the aim is to perform water management that is difficult to do manually, such as irrigation at night or early in the morning. However, it is important to note that the installation must be carried out within range of the radio waves from the communication equipment.

【Reference】 Example of estimated effects of introducing a Field-WMS and a Distribution-WMS (NIRE. 2019)

NIRE is currently calculating the effectiveness of the newly developed Field-WMS and Distribution-WMS based on a two-month demonstration test.

(1) Overview of the next-generation water management system

The target is a pump irrigation area covering 7.9 ha consisting of 11 paddy fields. Water is supplied to the fields directly from a pump via a pipeline. The analysis was carried out under the assumption that "WATARAS" would be introduced as the Field-WMS and "iDAS" as the Distribution-WMS. The demonstration test was carried out from July to August 2017, with iDAS installed at the irrigation pump station in the area and WATARAS installed at 15 water taps for the paddy fields.

An overview of the latest water management technology is shown in Figure 4.1.

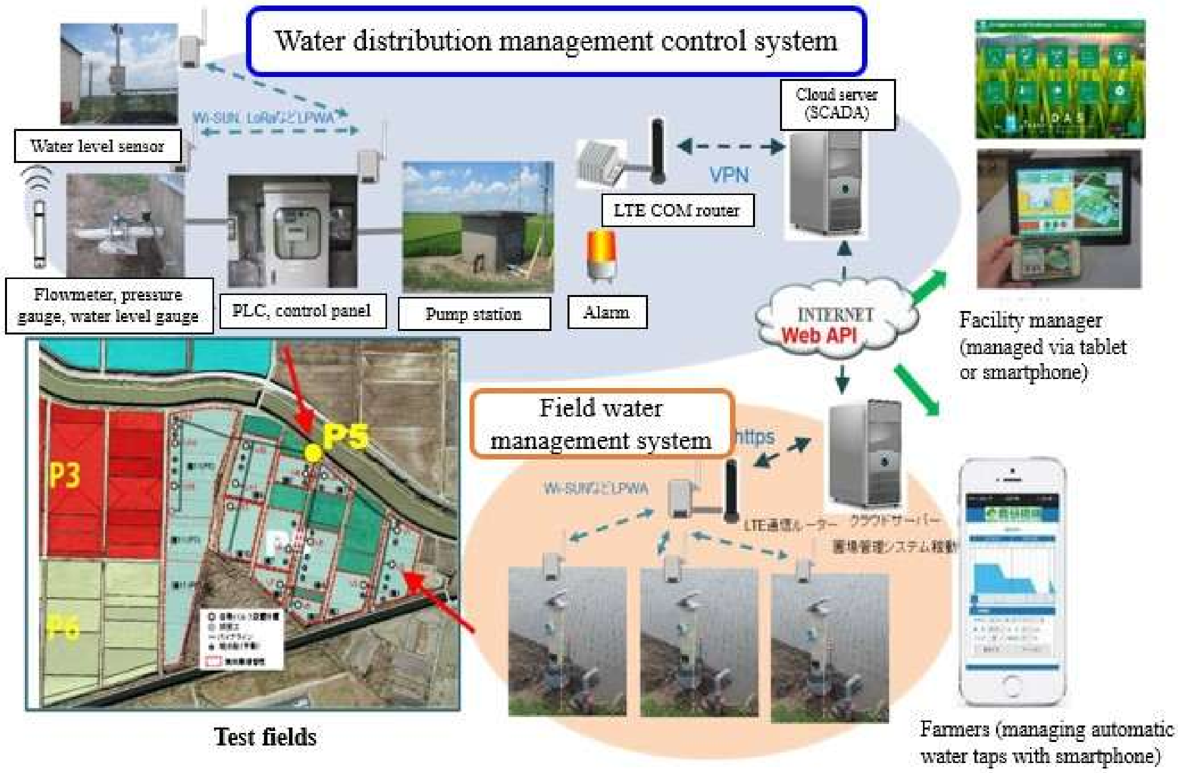


Figure 4.1 Overview of the latest water management technology

(2) Estimation of the effects of introduction

<u>Results of the demonstration test</u>

In paddy fields where the Field-WMS was introduced, almost no effort was required for water management by setting the certain water level according to the crop season in advance.

Figure 4.2 shows the results of pump output during the demonstration test period of the Distribution-WMS. By introducing this system and controlling pump output in accordance with flow rate fluctuations, it was possible to reduce pump output to an average of 60% compared to normal times. As a result, electricity charges for the reduced output were saved. In addition, because the system has a reservation control function, automatic daily control is possible by inputting the days the pump will be stopped in advance. By using this function, the effort required for pump management during the demonstration period was almost zero.

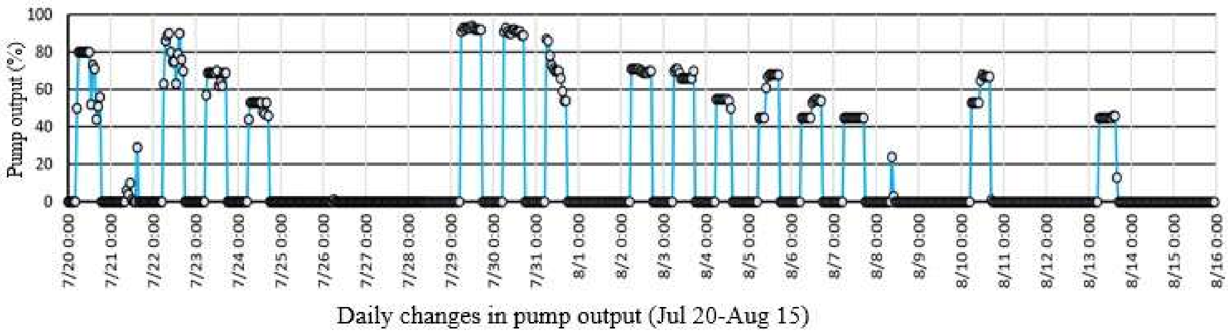


Figure 4.2 Changes in pump output during the demonstration test period

Estimation of initial investment and operating costs

The initial cost is the total investment amount related to the ICT water management system. The operating costs are calculated based on a 40-year evaluation period, including a one-year construction period, and include the related project costs and redevelopment costs during that period, as well as the asset value (negative expenses) for the final year. The useful life of the equipment is set at 10 years, and all equipment is to be replaced every 10 years. The base year is 2017, with planning in 2018 and construction to take place in 2019.

Running costs in subsequent years are present valued using a social discount rate of 4%.

The estimated present valued initial investment and operating costs are as follows:

- Initial investment: 5,326,000 yen
- Operating costs: 5,360,000 yen

Estimation of the effect of introduction

The introduction benefits were calculated based on the results of the demonstration test and only those benefits that were easy to calculate in a realistic manner. For the Field-WMS, the farming cost reduction effect (reduction in driving expenses and labor hours for field water management) was evaluated, while for the Distribution-WMS, the maintenance cost reduction effect (savings in driving expenses, labor hours, and electricity charges, and increased communication costs) was evaluated. In addition, the driving time reduction effect was estimated for each system. The estimated results of the introduction benefits are shown in Table 4.2. Note that, from the results of the demonstration test of the Field-WMS, increased rice yields (crop production effect) were expected as one of the effects, but this was excluded due to insufficient data.

Table 4.2 Example of estimated introduction effect

Item	Annual estimated benefit (thousand yen)		
	Benefits of introducing iDAS	Benefits of introducing WATARAS	Total
Reduced farming costs		154	154
Reduced maintenance costs	375		375
Reduced driving time	14	11	25

When calculating B/C by changing various conditions from the annual effect amount, if the social discount rate is 4%, B/C is about 0.9, but if it is 3%, it is well above 1.

4.2 Consultation with relevant organizations

- In discussions with relevant organizations in host countries regarding the overseas expansion of ICT water management technology, identify issues related to water management in the host country and propose solutions that utilize ICT technology. At that time, explain the advantages of ICT technology owned by Japanese companies. Also, fully explain how water management will be improved by this.
- It is desirable to conduct a demonstration survey and introduce ICT equipment on a trial basis to demonstrate the performance of ICT equipment. When selecting a model site for demonstrating ICT equipment, give priority to areas where improvement of water management is required. At this time, it is desirable to select a site where support can be obtained from local government organizations and WUAs. However, in areas where it is difficult to access mobile phone networks or the Internet, consider postponing installation or alternatively moving to another area with good communication conditions, taking into account the importance of water facilities and future plans for the development of wireless communication infrastructure.
- It is desirable to decide the installation location of ICT equipment on site in consultation with actual managers who are familiar with the local situation and issues, such as local organizations and WUAs. At that time, the concept of how the ICT equipment will be installed will be explained, and the ownership and management of the land on which the ICT equipment will be installed should be confirmed.
- After the ICT equipment installation plan at the model site has been finalized, a workshop for a demonstration study on ICT technology will be held to explain the plan to the local area and related organizations, and the consent of the relevant organizations in the host country will be obtained. If necessary, a memorandum of understanding regarding the demonstration study will be concluded.

(1) Consultation with relevant organizations

- When identifying issues related to water management in the host country, use examples of cooperation by Japan to the host country (yen loan projects, grant aid projects, technical cooperation projects, development studies), and examples from the Asian Development Bank and the World Bank, and related literature.
- When proposing solutions to issues using ICT technology, use PowerPoint materials or other materials to specifically explain the benefits to the host country's irrigation water management organizations. However, in countries that prioritize securing employment for workers in irrigation systems within the region, the host country may not understand if the benefit of reducing the number of water management staff is cited.
- When explaining Japan's ICT water management technology, explain examples of its use in Japan and in other countries. In the case of Southeast Asia, explaining examples of its use in ASEAN countries and its useful life will increase the reliability of the proposed ICT equipment. At that time, questions will inevitably be asked about the natural conditions of the ICT equipment's installation location, the price, maintenance costs, usage fees, and other costs, so it is necessary to prepare materials in advance.
- By utilizing ICT technology, it is possible to obtain water level data, which can prevent water disputes through appropriate water allocation based on data and stabilize water intake flow rates. Examples of cases where irrigation efficiency has improved as a result will be introduced.

(2) Selection of model site

- Model sites for installing ICT equipment and demonstrating its effectiveness are selected in consultation with relevant organizations in the host country, based on set criteria such as irrigation districts that are candidates for the host country's irrigation modernization plan, districts with reservoirs, and districts close to regional central cities where a large demonstration effect is expected. In doing so, information is obtained about local water management organizations and government agencies, and multiple sites are visited, each of which is evaluated according to the selection criteria.
- When selecting a model site, factors such as the soundness of the irrigation facilities, the activity status of the water management organization, the status of mobile phone communications, and the difficulty of installing ICT equipment must also be taken into consideration.

(3) Selection of ICT equipment installation locations and installation methods

- Possible locations for installing ICT equipment include dam intakes, weir intakes, the start of main canals, and diversion works. Also, to avoid issues with land rights adjustment, the promoter will consider whether it is possible to install the equipment on the grounds of irrigation projects owned by the national or local government, where it is expected that the risk of theft is low and vehicle traffic and crop cultivation will not be impeded. At the installation site, in the presence of relevant parties, the promoter will mark the location with spray paint, read the GPS coordinates of the location, take photographs, and ask about water management methods, etc., for later local explanations.
- It is necessary to gain the understanding and cooperation of the local community to install ICT equipment. The promoter will explain the situation to local residents at every opportunity, and present the agreement documents (MOM, MOD, etc.) regarding the installation of ICT equipment concluded with the host government.
- After a preliminary survey of the site, the promoter will consider and design an installation method for ICT equipment that can appropriately observe water levels, rainfall, water quality, etc. and prevent theft. Based on this design proposal, the promoter will consult with relevant organizations and take into account the possibility of procuring materials, then the promoter will create design drawings, calculate quantities, and estimate construction costs.

(4) Conclusion of the agreement

- When conducting a demonstration study on ICT equipment, a draft agreement document (MOM, MOD, etc.) is presented to the relevant organizations, and a preliminary explanation is given in the form of a workshop to the relevant organization's staff and local stakeholders.
- When discussing the agreement document, stakeholders often express reluctance to include mention of tax exemption measures for ICT equipment. In cases where there is no comprehensive tax exemption clause, as in the case of JICA, the host country organization must individually go through the domestic procedures for tax exemption measures. The following documents are required to obtain tax exemption measures:

  - Details of ICT equipment (quantity, total amount, specifications, number of experts to be dispatched, man-month)
  - Obtaining a request from the implementing agency of the host country to the customs authorities

- In order to facilitate smooth development in the future, it is necessary to clarify intellectual property rights regarding ICT equipment.
- It is necessary to explain the draft agreement to the host country as early as possible. In many countries, the more parties involved, the longer it takes to obtain approval.

4.3 On-site survey and design, etc.

- Confirm with the person in charge on-site the installation locations desired by the local relevant agencies for the ICT equipment. Check the local communication conditions at the candidate ICT equipment installation sites.
- Based on the results of the on-site survey, carry out the design, quantity calculations, and cost estimates for the installation of the ICT equipment. At that time, give careful consideration to measures to prevent theft of the ICT equipment. Confirm the unit price of construction with the local relevant agencies. Also obtain local information on material procurement, production, etc., and create a construction process plan.
- If necessary, conduct flow observations to create a water level-flow rate equation (HQ equation). Regarding flow rate observations, consult with the relevant agencies and decide on the department or agency in charge of observations. Before conducting flow observations, confirm the implementation method, implementation structure, and observation equipment. After flow rate observations are completed, conduct a completion inspection. After creating the HQ curve, import it into the server's program, and convert the water level received by the ICT equipment into a flow rate for display.

(1) Field survey

- The locations for installing ICT water management equipment will be selected from among important water management points such as important irrigation facilities, water intake works, check gates, and diversion gates, at locations that are most efficient for observing water levels, water quality, and rainfall. As a general rule, ICT data is transmitted using the communications networks of mobile phone companies (carriers), SIM cards from multiple carriers that are frequently used in the country will be prepared, and the carrier with the best performance for mobile phone transmission at the candidate locations for ICT equipment will be selected.
- If possible, it is best to bring a spare communications device from the planned ICT manufacturer to the site and directly compare the communications conditions for each carrier (Photo 4.1).

Photo 4.1 Checking communication status using spare communication equipment in Cambodia

(2) Design and Cost Estimation

- One of the biggest challenges for ICT equipment is preventing theft. The first step in preventing theft is to understand the local theft situation. Metallic materials, which are usually sold in the market, are at high risk of being stolen, so the use of metallic materials is minimized and the paint and shape are designed so that they are not recognizable from the outside. ICT equipment is becoming lighter, so it can be easily attached to steel pipes. However, metal is easily stolen from areas where theft is a risk. One method is to erect a PVC pipe with an inner diameter of 200 mm or more vertically, reinforce it with a cage rebar, pour concrete, and build it as a support pipe, and then attach the ICT equipment to the top of this. This minimizes the use of metal and installs the equipment at a height of 4 m or more, preventing theft and minimizing the amount of land occupied (Figure 4.3, Photo 4.2).

- Drawings and quantity calculations for the installation of ICT equipment are prepared for ordering from local contractors, so care must be taken to make them easy to understand and avoid misunderstandings, and any necessary parts are translated into the local language.

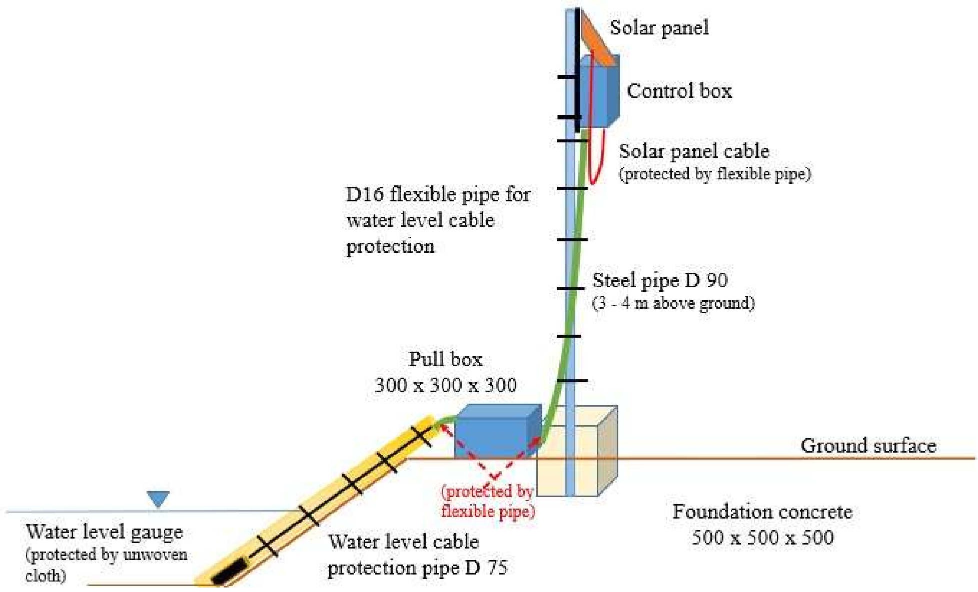


Figure 4.3 Installation example of ICT communication equipment and water level sensor (pressure type)

Photo 4.2 Example of installation of ICT communication equipment with anti-theft measures taken into consideration

(3) Flow Observation

- Flow observation is outsourced to the relevant department of the local organization or to an experienced person from a local university. Usually, it is outsourced to a local organization. When outsourcing, the observation instrument (current meter), observation method, observation position in the cross section of the channel, and outsourcing fee are discussed in advance. In addition, since flow observation in a large main canal needs to be performed from a boat, safety measures such as wearing life jackets are mandatory (Photo 4.3).
- Observation conditions are recorded with photos and videos, and progress is regularly reported. If water is taken by operating a gate, the water depth for flow observation can be changed by operating the gate. However, in natural rivers and natural waterways without gates, it is necessary to wait for the timing of flow observation at the planned water depth while comparing the water depth data of the ICT equipment with the forecast value of rainfall. In addition, since the flow velocity increases as the water depth increases, safety measures must be strengthened as the water depth increases.
- The HQ formula is created on-site by measuring the average flow velocity in a canal according to the water level and multiplying it by the cross-sectional area to calculate the flow rate. Because it may not be possible to freely adjust the water level during a survey, the HQ formula for unmeasured water levels is estimated by extrapolation, and a clear distinction should be made between the actual measured range and the extrapolated portion of the HQ curve.
- To obtain an accurate HQ formula, flow observations are conducted, especially during periods of high water levels, and the HQ formula is revised based on the additional data. The HQ curve is incorporated into the display software of the ICT equipment, which displays water depth and flow rate simultaneously.

Photo 4.3 Flow observation situation (Left: Indonesia, Right: Thailand)

4.4 Installation of ICT water management equipment

- Contracts for ICT equipment installation work will be prepared in both English and the local language, and in the event of any doubt, the English version will take precedence. The contract will clearly state safety measures during construction and who is responsible. Regarding payment for construction costs, the advance payment rate and payment timing will be clarified. Construction procedures will be discussed with the contractor (or irrigation association, etc.) undertaking the work before construction begins.
- Whenever possible, be present during construction work. Take sufficient care when working at heights, and give due consideration to safety measures for scaffolding for workers. Equipment will be installed by engineers from the ICT equipment manufacturer, who will provide on-site instruction to staff from relevant agencies on how to connect cables and manage TMs.

(1) Conclusion of contract for ICT equipment installation work

- Contracts for ICT equipment installation work will be prepared in both English and the local language. The contract will specify the location, quantity, cost, construction period, etc. as well as safety measures during construction and who is responsible in the event of an accident. Safety measures will be discussed in advance and confirmation will be made that appropriate scaffolding is in place. When installing anti-theft protection measures that involve working at height, the wearing of safety harnesses will also be considered.
- The construction contract amount and payment method will be stated in the contract. The construction procedures will be confirmed in advance and the amount and timing of advance payments and interim payments will be decided. Local contractors will use advance payments to purchase materials and hire workers, so if these amounts are not reasonable, it will lead to delays in the process. It is common practice for interim payments to be made every two weeks, so this should be confirmed in advance. Payments will mainly be made in local currency, but there may be cases where payments are made in US dollars, so it is important to check the exchange rate between the dollar and the local currency whenever possible.

(2) Checking the construction status

- Checking the construction status is necessary for construction management, confirmation of progress and safety measures, and interim payments.
- From the perspective of safety management, it is important to confirm the construction procedures with the contractor in advance, check the construction status, and check the scaffolding when working at height.
- When connecting the ICT equipment control box that houses the communication device to the cables of the solar panel and sensor, care must be taken as electronic devices are being handled. In addition, the initial setup of the communication device involves connecting a laptop computer to the communication board with a USB serial cable and entering values from the computer, so it is necessary to provide on-the-job training to the relevant agency personnel on how to set it up. In addition, if there are many ants in the installation location and it is anticipated that living organisms may invade the ICT equipment control box, preventive measures to avoid damage from living organisms, such as placing anti-ant and insecticide inside the box, should be taken.

4.5 Data analysis and consideration of improvements to water management systems

- By checking water level data obtained from ICT equipment as needed and comparing it with the planned water level, it is possible to change the gate opening degree or the planned water level as necessary, thereby improving water management.
- Workshops will be held on a regular basis for local agency personnel and water users association members to share and resolve any newly arising issues, promoting the sustainable use of ICT equipment. In addition, opinions will be exchanged with relevant agencies on the future development methods for networking ICT water management systems.

(1) Receiving and analyzing data

- Comparing the irrigation volume in the irrigation water allocation plan for the year with the actual irrigation volume is important to gain the understanding of the relevant agencies. In the field, visual observation of the water level at the water gauge is performed, so it is necessary to ensure consistency between the data from the ICT equipment and the readings on the water gauge. If the elevation of important water utilization structures such as the crest of a fixed weir is known, the water depth can be converted to water level, but it is rare to obtain the elevation. The accuracy of the water depth of the ICT equipment is confirmed by matching the water gauge reading (water depth) with the water depth of the ICT equipment.
- At headworks and diversion works, water gauges are installed after construction is completed, and the flow rate against the water gauge reading is often summarized in a table. After creating the HQ formula, it is necessary to check the consistency by comparing it with the existing water gauge reading-flow rate table.
- Irrigation water is usually allocated by flow rate, so if an existing water gauge reading-flow table is changed at one diversion work, it will have an impact downstream, and the water gauge reading-flow table for the entire irrigation system will need to be changed. In irrigation systems that have been completed for a long time, water allocation has become a custom, so it is undesirable to change this custom by introducing ICT equipment. In water management based on numerical values using ICT equipment, it is a good idea to consider a new transition from flow rate management to water depth management, which is unrelated to water gauge reading-flow table. This is a method in which the actual flow rate management results are replaced with the water depth from the ICT equipment to set it as the actual water depth, and the water depth is managed within a plus or minus fluctuation range, based on the fluctuation in water depth from the year with the highest crop yield. This makes it possible to eliminate the need for flow rate calculations.

(2) Examination on improving water management systems based on water level data

- Once a certain amount of water level data for the dry and rainy seasons has been accumulated, it can be compared with the irrigation seasonal water distribution plan for that year prepared by the irrigation-related organizations to estimate the water intake and discharge situation based on the data from the ICT equipment. It is also necessary to hear from the local related organizations about irrigation efficiency and water saving rates. Agricultural production data and planting rate during the period of efficient irrigation, as well as the ICT equipment water level data, will become basic data for irrigation water management and lead to improvements in irrigation water management (water level management) in future.
- In order to promote a change in the awareness of the top management of the organizations in charge of irrigation,

it is very important to share information with beneficiaries, local related organizations, and responsible departments of the competent government agencies on (1) how ICT equipment is installed and maintained, (2) how the observed ICT data is used in daily water management, and (3) what effects it has. It is important to hold workshops regularly, locally and centrally. In the workshop, the above three points are repeatedly explained, and participants are also presented with how they have worked together to solve the problems on the ground, which is an important way to change their mindset.

- As participants confirm the effectiveness of ICT water management in workshops, etc., the proposal to build an ICT water management network for the entire irrigation district is discussed. Areas hoping to build an ICT water management network are often areas where water management issues have been a source of contention for a long time. For example, there have been frequent disputes over the amount and period of water diversion at water diversion works for many years. It seems that many local related organizations and WUAs would like to "visualize" the issues based on concrete data and resolve the issues through local discussions about how to open and close the gates. It is necessary to conduct on-site surveys of water structures with WUA officials and consider installation plans for ICT equipment. The installation plans for ICT equipment in the irrigation system are integrated into the network proposal and may serve as basic information for project implementation by domestic or foreign aid organizations.

5. Post-project maintenance

Management of ICT equipment, etc.

- After the demonstration period for the ICT equipment in the model site ends, the equipment will be transferred in accordance with the rules of Japan and the host country (such as property disposal).
- In order to ensure the security of the ICT water management system, management of the database and the web server will be separated to prevent external access to the database, and an ID and password will be set for access to the web server.
- A system administrator manual and user manual on how to use the ICT equipment will be prepared in both English and the local language.
- To ensure that the ICT equipment is properly maintained after its transfer, an equipment maintenance manual will be prepared and, if possible, practical training will be provided locally.

(1) Transfer of TM equipment

- When transferring ICT equipment, it is necessary to clarify the rules and necessary documents for the transfer procedure as soon as possible and prepare documents in accordance with the procedures of the host government. Since detailed information such as the equipment's specifications is required, it is necessary to organize basic information related to the specifications at the time of purchasing the equipment. It is also necessary to confirm the name of the organization receiving the equipment and the person who signed the transfer document.
- Since the maintenance costs of the ICT equipment after it is transferred are borne by the host organization, the organization must request a budget at the latest in the year before the transfer in order to secure the necessary maintenance budget. It is necessary to calculate the communication costs required for maintenance (mobile phone network usage fees), cloud usage fees, miscellaneous materials (desiccant, ant repellent, insecticide, etc.), labor costs, etc.

(2) Ensuring security

- Users of ICT equipment data access clouds or physical servers via the Internet to obtain ICT data. Many physical servers in developing countries do not use HTTPS, which encrypts communications, due to the expense. This not only creates security vulnerabilities, but also means that web-based applications cannot be used and TM data display software may not function.
- Some ICT equipment manufacturers limit the number of people who are granted access and enforce strict password management, but incorrect password entries can frequently lead to system lockdowns.
- Administrators of ICT systems must decide whether to limit access to ICT equipment data or to make it public. To make ICT data widely available to stakeholders, including beneficiaries, it is desirable to move closer to making the data public. Security is tightened so that only administrators can access the database, while a method is available that allows users to log in to the display system by entering an ID and password specified for the system.

(3) Creation of system administrator manuals and user manuals

- Two types of manuals will be created for the ICT data display software: one for the system administrator and one for users, such as those in charge at related agencies and local WUA personnel.
- The manuals will use many diagrams and photographs to make them easy to understand, and technical terms that are difficult to rephrase will be annotated and compiled into a glossary. Two types of manuals will be created, one in English and one in the local language. When translating into the local language, great care should be taken to ensure that the concepts of technical terms match those in English.

(4) Maintenance after transfer

- After the transfer of ICT equipment, a manual will be prepared to ensure that the equipment is properly maintained. The maintenance manual should mainly consist of diagrams and photographs, and be designed to make the necessary work easy to understand. The contents of the maintenance manual should be as follows:

    - Tools and consumables required for maintenance
    - Inspection points for water level sensors, rain gauges, water quality sensors, etc. and methods for calibrating observed values
    - How to clean equipment (water level sensors, rain gauges, water quality sensors, solar panels, control boxes)
    - List of spare parts for major equipment
    - Inspection methods in case of system abnormalities
    - Contact information and email addresses for ICT equipment manufacturers

- The maintenance manual is used in on-site training at the draft stage, and any flaws are corrected. At this time, photos or videos are taken for each step of the work, and these are reflected in the visual explanations of the manual's contents.
- When the water level gauge is replaced, or when an error occurs when comparing the ICT data with the water level gauge reading, the ICT equipment data is corrected. Corrections can be made on the ICT side or on the software. Corrections made on-site are possible on the ICT side, so after the ICT equipment is installed, the relevant agency staff are instructed on how to make corrections through OJT based on the manual. However, as corrections are made once every year or several years, if the staff changes, they will no longer know how to make the corrections. It is necessary to establish a communication system between the ICT equipment manufacturer and local staff so that the ICT equipment manufacturer's administrator can correct the errors on the software if the errors become too large.

ICT equipment maintenance

- Maintenance work is essential to ensure accurate, long-term measurements using ICT equipment.
- It is necessary to regularly check measurement data and remove weeds and clean ICT equipment, including sensors.
- To continuously transmit measurement data, it is necessary to monitor the equipment to prevent communication interruptions due to insufficient SIM card charges with the carrier.

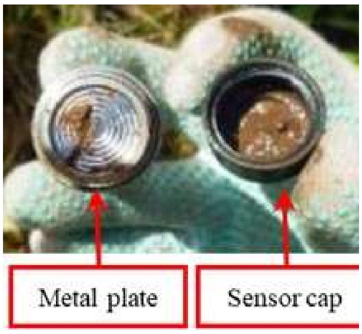
Cleaning the communication device

- Control boxes are prone to attack by ants and insects, so take necessary measures and inspect them regularly.
- During inspections, apply insect repellent and exterminate ants and insects around the equipment.
- Regularly replace the desiccant inside the box to keep the inside of box dry.

Cleaning the solar panel

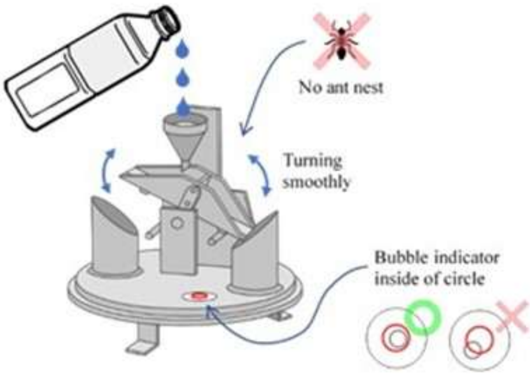
• Spray the solar panels with clean water at least once a year and wipe them with a soft cloth. • Check the battery voltage regularly to ensure that the solar panel is functioning properly. • Check the cable connections and sealing of openings to prevent the intrusion of ants and other pests.	 

Cleaning the sensors

• If the sensor is not maintained, abnormalities will occur in the measurement data, so clean and inspect it at least once a year. • Carefully pull out the water level sensor cable and clean the sensor. • Remove the sensor cap and wash the cap and inside with clean water. • Record the date and time of the maintenance work.		
		

Cleaning the rain gauge

- Insects, dirt and other foreign objects will adhere to the rain gauge body.
- Inspect and clean the screen regularly.
- To clean the body, disconnect the rain cable and remove the rain gauge body, then clean the tipping bucket with water, a cotton swab and a soft cloth.
- After cleaning, check that the tipping bucket moves smoothly and that the air bubble in the spirit level remains centered.
- Tighten the screws to reset the body and reconnect the cable.



Cleaning the water quality sensor

- Water quality sensors need to be cleaned regularly and frequently. Insects may be attached to the sensor.
- After cleaning, calibrate the sensor.

Fixing data anomalies

- Data abnormalities include delays, interruptions or halts in data transmission, and the occurrence of abnormal values.
- Causes of data transmission abnormalities include a malfunction in the communication device, an insufficient or expired SIM card, an abnormality in the solar panel (theft, insufficient capacity, dirty or damaged panel), and battery deterioration. It is necessary to identify the cause and take appropriate action while checking the current state of the ICT equipment and checking each possible cause.
- If the communication device and battery are normal but there is an abnormality in the data itself, possible causes may be a dirty sensor or a malfunction.

(1) Communication error

- When data is no longer being transmitted from a sensor, the cause is often related to the SIM card, such as the SIM card having run out of charge or the expiration date. If the charge has run out, the manager can access the carrier via the Internet to top up, but in some countries, the manager may not be able to access the carrier via the Internet. For security reasons, especially when conducting demonstration tests of ICT equipment in model areas, foreigners can only purchase prepaid SIM cards, and the SIM card problem often remains unresolved. When transferring ICT equipment after demonstration tests, the host institution must purchase a SIM card from a domestic carrier and replace it with the SIM card in the communication device used in the demonstration test.
- ICT equipment is often manufactured to support LTE or 4G, which have stable communication, and when using a 5G SIM card locally, switching to the communication equipment's modem may be unstable, resulting in unstable data transmission. In such cases, it becomes necessary to use a SIM card from a carrier that does not provide 5G service, or to replace it with equipment that supports 5G.
- When not using grid power, the communication device runs on solar panels and batteries. Solar panels can be used for a long time if inspected regularly, but batteries wear out and should be replaced every 3 to 5 years. When the battery deteriorates, a specific communication problem occurs, where signals are transmitted intermittently during the day but not at night (Figure 5.1).
- In communication devices, the high temperatures and high voltage loads inside the control box can cause deterioration of the terminal connections and lead to failure. Ants and other insects can also invade the control box and build nests, cutting off the lines inside the box. The inside of the box and communication devices should be inspected and cleaned regularly, and the voltage and resistance should be measured with a tester to make sure they are within the normal range. If replacing the battery or terminals does not restore normal operation, it is appropriate to replace the defective device with a new one and send it to the manufacturer to have the cause investigated.

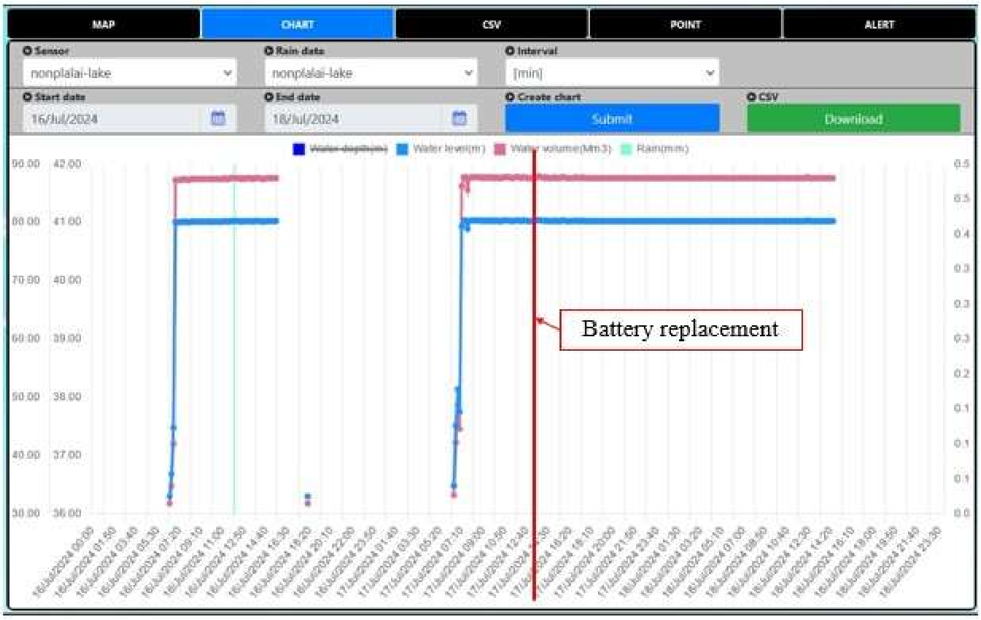


Figure 5.1 Normalization of water level data transmission abnormality after battery replacement (Thailand)

(2) Data abnormality

- Data anomalies are caused by a dirty sensor, a problem in the connection with the communication device, or a malfunction of the sensor itself.
- Because the price of sensors is falling, it is often more advantageous in terms of life cycle costs to replace a sensor with a new one than to repair a malfunction, as this will also increase its service life.

(3) Data calibration

- If a water gauge is installed at a critical structure, and the error when comparing the water level reading on the gauge with the water level on the ICT equipment exceeds the allowable value, the correction value should be changed in the system to match the water level on the ICT equipment to the value on the water gauge.
- At locations where there is no water gauge, the water depth is measured using a fishing line or something similar during regular inspections and compared with the water depth on the ICT equipment (Photo 5.1). If the difference between the actual measurement and the ICT value exceeds the allowable range, the correction value should be changed in the system to match the water depth on the ICT equipment to the actual measured depth.
- Water quality sensors will indicate abnormal values if the sensor becomes dirty, so they require inspection and calibration at least once every three months. Each manufacturer has its own calibration method, which uses a standard solution.

Photo 5.1 Measuring water depth using a fishing line (Left: Thailand, Right: Vietnam)

References

(in alphabetical order)

Brian Wahlin, Darell Zimbelman. 2014. “Canal Automation for Irrigation Systems: American Society of Civil Engineers Manual of Practice Number 131.” American Society of Civil Engineers (ASCE)..

Ministry of Agriculture, Forestry and Fisheries. 2023. “Guide to Introducing Water Management Systems Using ICT.” Ministry of Agriculture, Forestry and Fisheries (MAFF), Rural Development Bureau, Development Department, Water Resources Division.

NIRE. 2019. “Next-generation Water Management System Introduction Guide.” National Agriculture and Food Research Organization (NARO), Institute for Rural Engineering (NIRE).

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