Smart Water Management (SWM)

United Nations
Educational, Scientific and
Cultural Organization

i-WSSM
International Centre for
Water Security and
Sustainable Management

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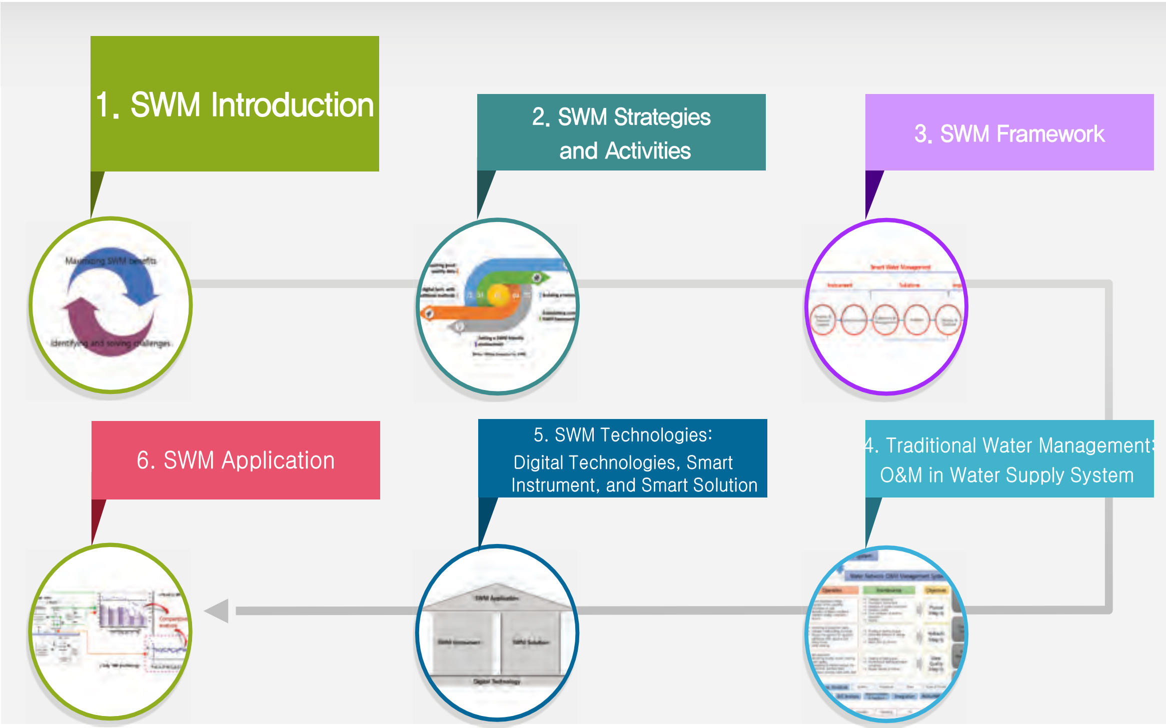
Smart Water Management Introduction

Smart Water Management

1. Smart Water Management Introduction

United Nations Educational, Scientific and Cultural Organization
i-WSSM
International Centre for Water Security and Sustainable Management

Training Course



Aims & Objectives

- The aims of the course are to:

(1) Provide an overview of the paradigm shift in the water sector, smart water management, and benefits and challenges in SWM implementation;

(2) Enable trainees to grasp and identify in advance the benefits and challenges that may arise when SWM is implemented into their system

- The objectives are that trainees will understand:

(1) The reason SWM emerged;

(2) Necessity of SWM applications;

(3) Problems that may occur when applying SWM

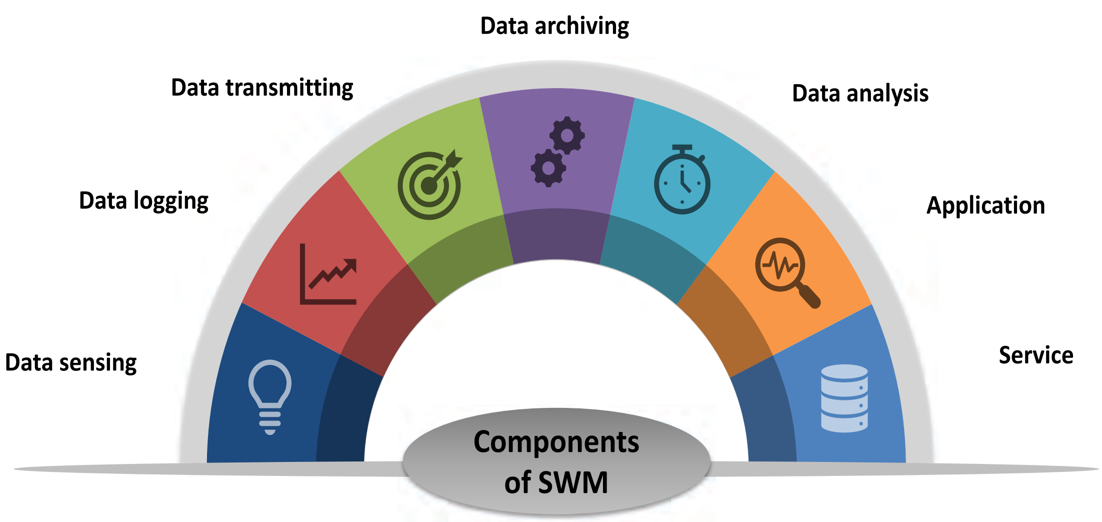
Contents

1. Paradigm Shift for Water Utilities
2. SWM Concept
3. Benefits of SWM
4. Challenges in SWM Implementation

1. Paradigm Shift for Water Utilities

1.1 Current Status (1)

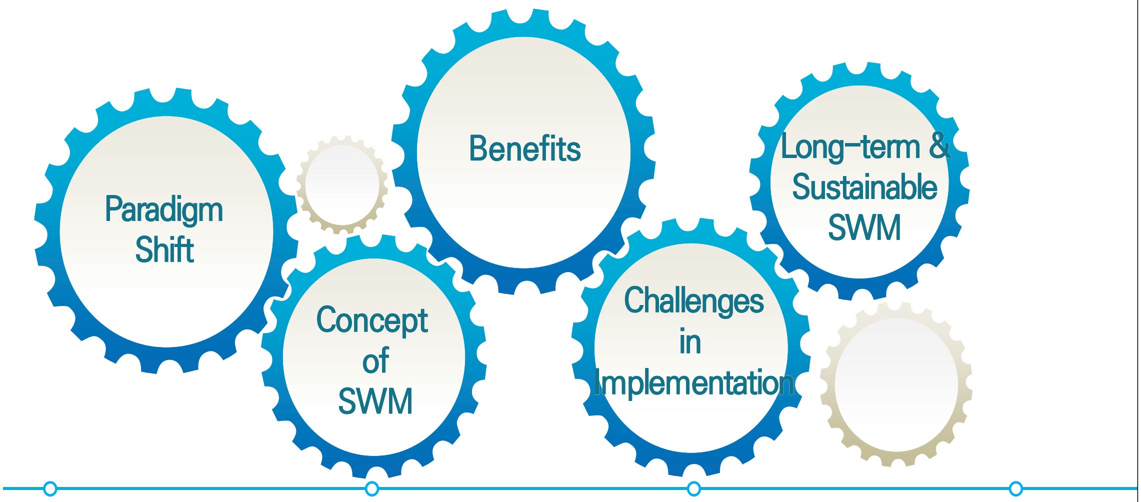
- (Popularity) Smart water management (SWM), including data sensing, logging, transmitting, archiving, analysis, application, and service in the water system, is currently gaining a lot of attention from the governments, industries, academia, and water utilities



[Main Components of Smart Water Management]

1.1 Current Status (2)

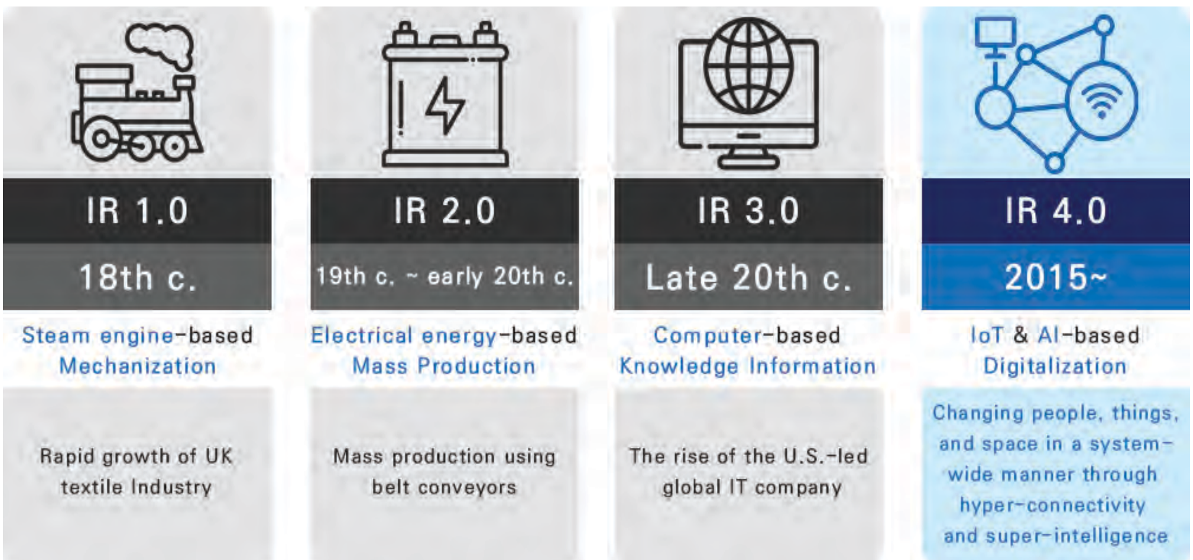
- **(Keys to success) To successfully implement SWM, water utilities must clearly understand the paradigm shift in water management, the concept of SWM, application benefits, and challenges in SWM implementation**
  - The paradigm shift in water management, the concept of SWM, application benefits, and challenges in SWM implementation are described in detail in chapter 1, 2, 3, and 4, respectively



[Keys to Long-term & Sustainable SWM]

1.2 Industrial Revolution 4.0 (1)

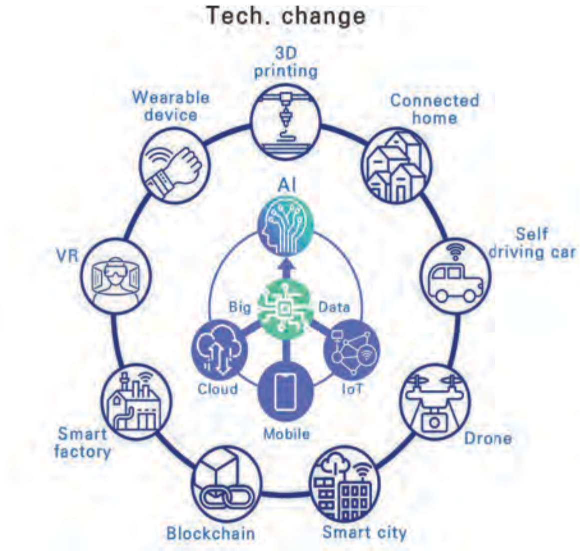
- **(IR 4.0) Digital technology based fourth industrial revolution are change people, things, and space in a system-wide manner**



[Four Industrial Revolutions]

1.2 Industrial Revolution 4.0 (2)

- (Digital technology) IoT, AI, Cloud, Mobile, and Big data have been innovating industrial structure and social system in smart city, smart factory, VR&AR, self-driving car, 3D printing, etc.



[Digital Techologies]

1.2 Industrial Revolution 4.0 (3)

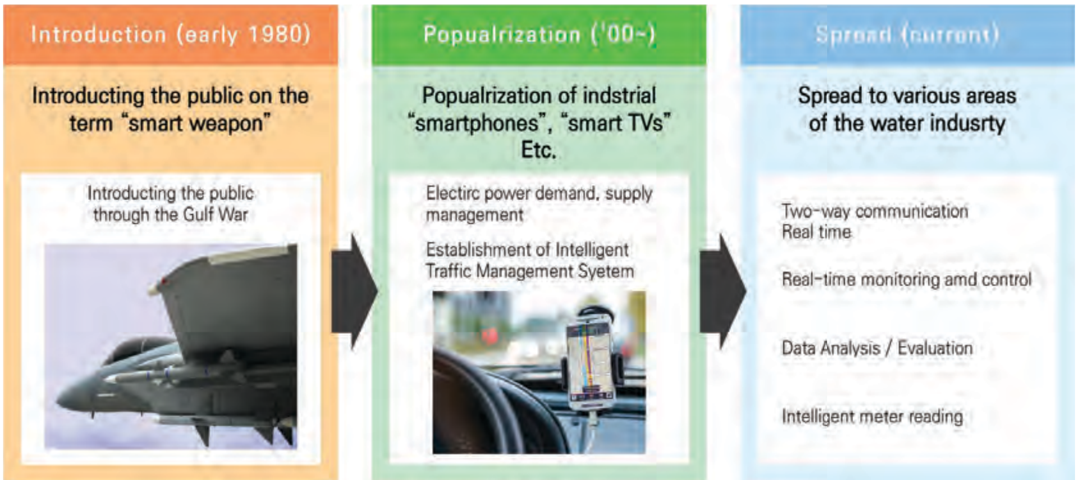
- (IR 4.0 & water management) Innovative changes in water management is emerging under the influence of IR 4.0

[The Effect of IR 4.0 on Water Management Technology]

Source: MOTIE, 2016

1.3 Paradigm Shift from Traditional to Smart (1)

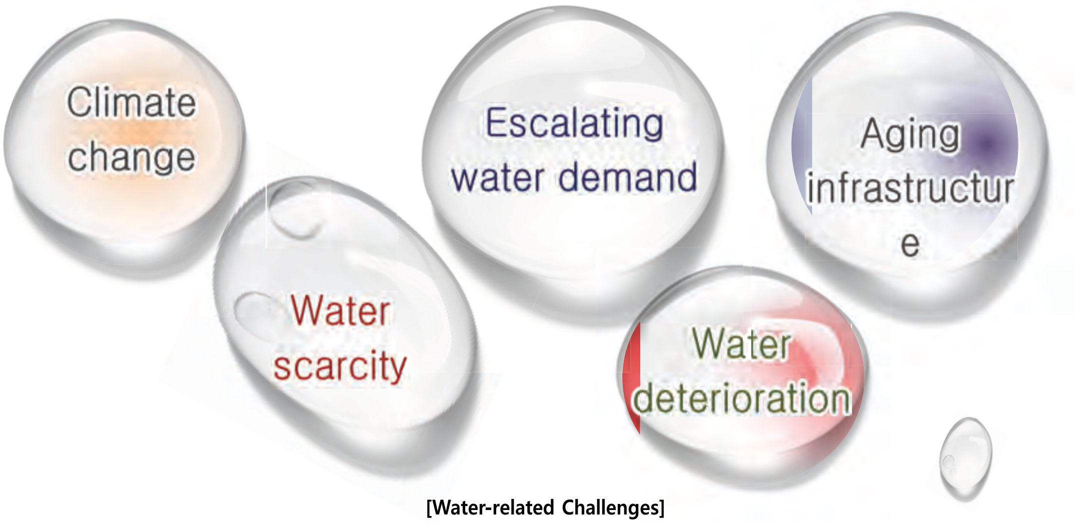
- (Smart concept) "Smart" is a concept that enables real-time and efficient response with the cutting-edge instruments, techniques, and solutions



[Implementation of Smart Concept]

1.3 Paradigm Shift from Traditional to Smart (2)

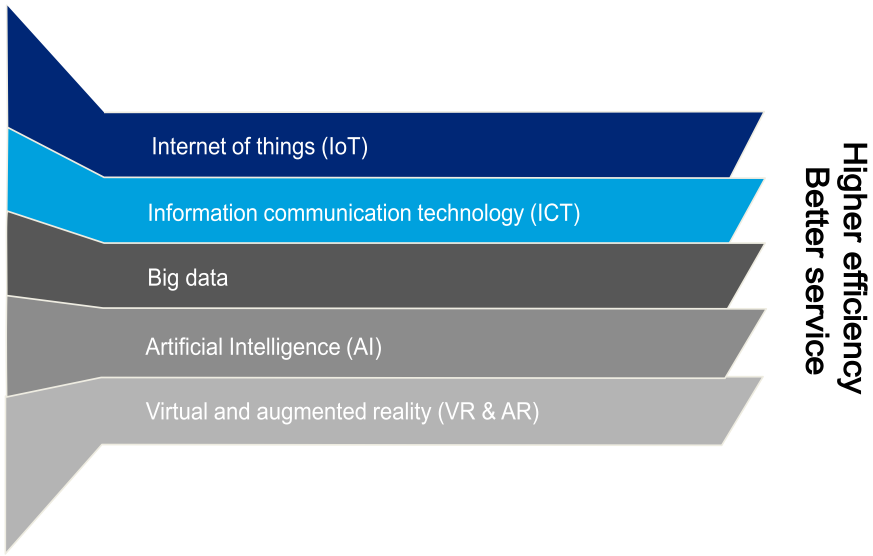
- (Water-related challenges) Mounting global water-related challenges such as climate change, water scarcity, escalating water demand due to population growth and urbanization, water deterioration, and aging infrastructure place more pressure on water utilities than ever before



[Water-related Challenges]

1.3 Paradigm Shift from Traditional to Smart (3)

- (Digital technologies in water) Water utilities can have a chance to leverage advanced digital technologies for higher efficiency and better service without large infrastructure costs



[Advanced Digital Technologies Contributing Higher Efficiency and Better Service in Water Management]

1.3 Paradigm Shift from Traditional to Smart (4)

- (Paradigm shift) Water utilities should embrace change, find ways, and shift from traditional water management to SWM to alleviate and solve current water challenges

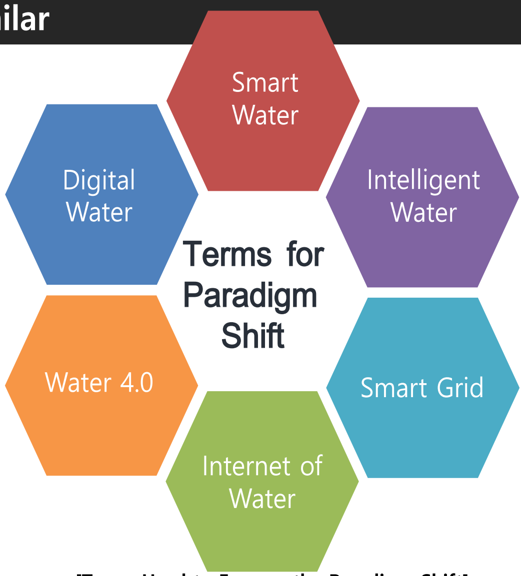
[Shifting from a Traditional Water Management to a Smart Water Management]

2. SWM Concept

2.1 Definition
2.2 Smart Water Management
2.3 Characteristics of SWM
2.4 SWM Implementation Groups

2.1 Definition (1)

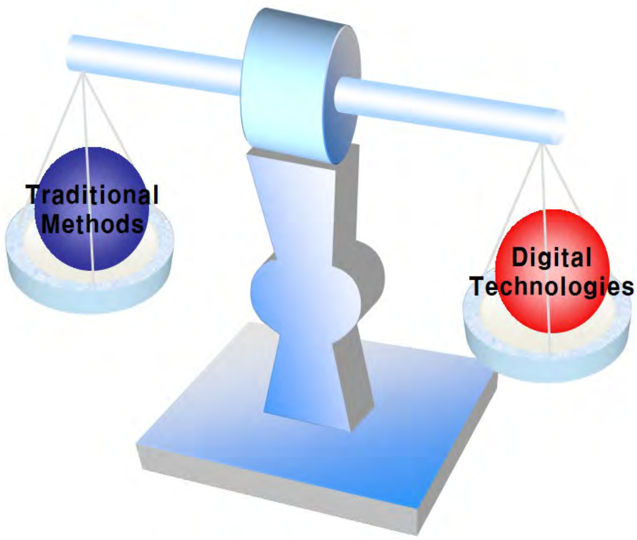
- (Various terms for paradigm shift) The terms “digital water”, “intelligent water” “smart water grid”, “smart water”, “internet of water” or “water 4.0” have been widely used to express the paradigm shift
- (Similarity) Actually, the underlining concepts, principles, and objectives in these terms are similar



[Terms Used to Express the Paradigm Shift]

2.1 Definition (2)

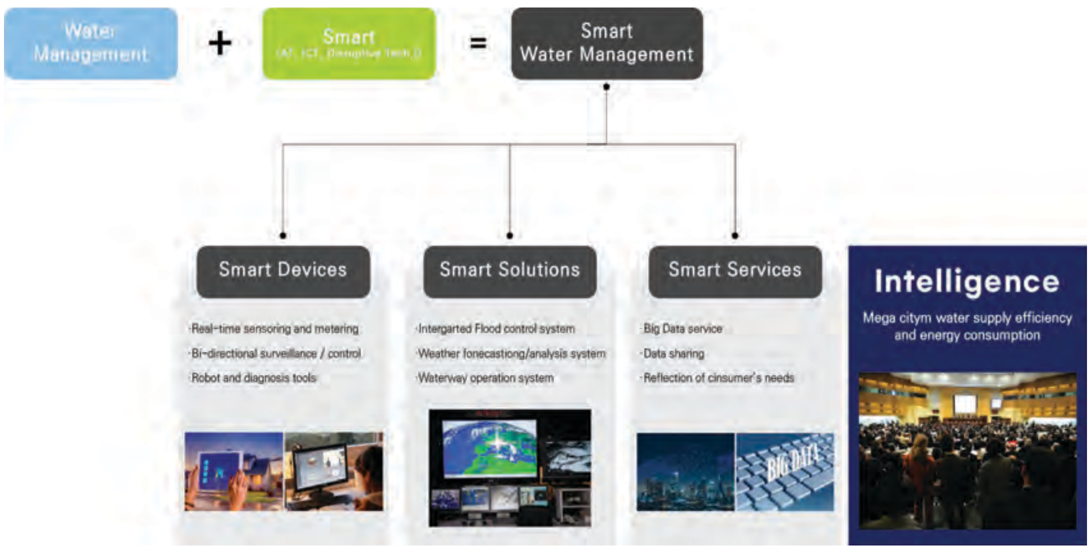
- **(Suitability of SWM) Since the integration of traditional water management and digital technology are the keys of the success, SWM is a suitable term for expressing paradigm shift.**



[Balancing the Traditional Methods and Digital Technologies in Smart Water Management]

2.2 Smart Water Management (1)

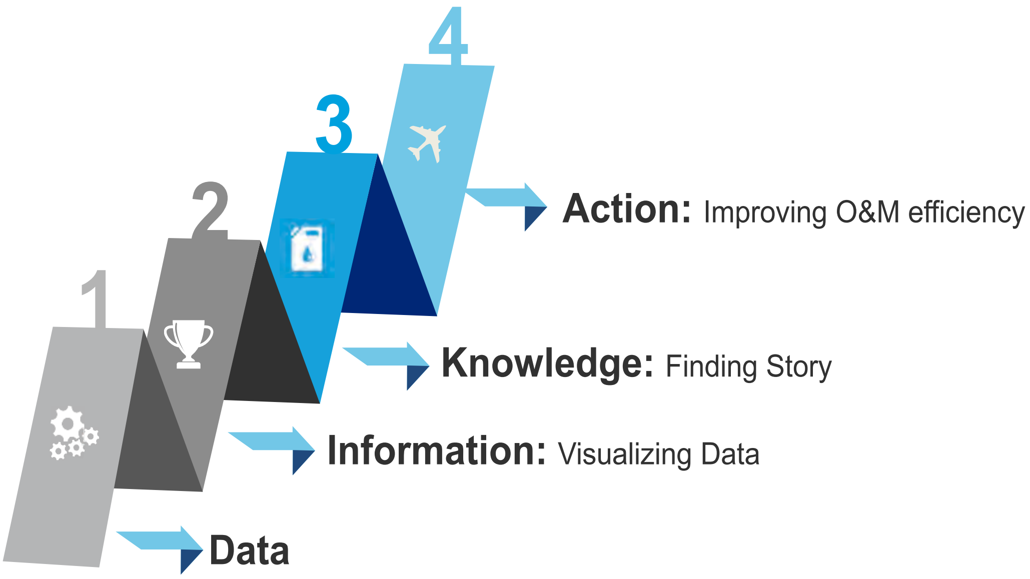
- **(Definition) SWM is not a single or alternative technology, but a new water management paradigm**
  - Water utilities should seek an alternative, smart and novel way to improve water management efficiently



[Smart Water Management]

2.2 Smart Water Management (2)

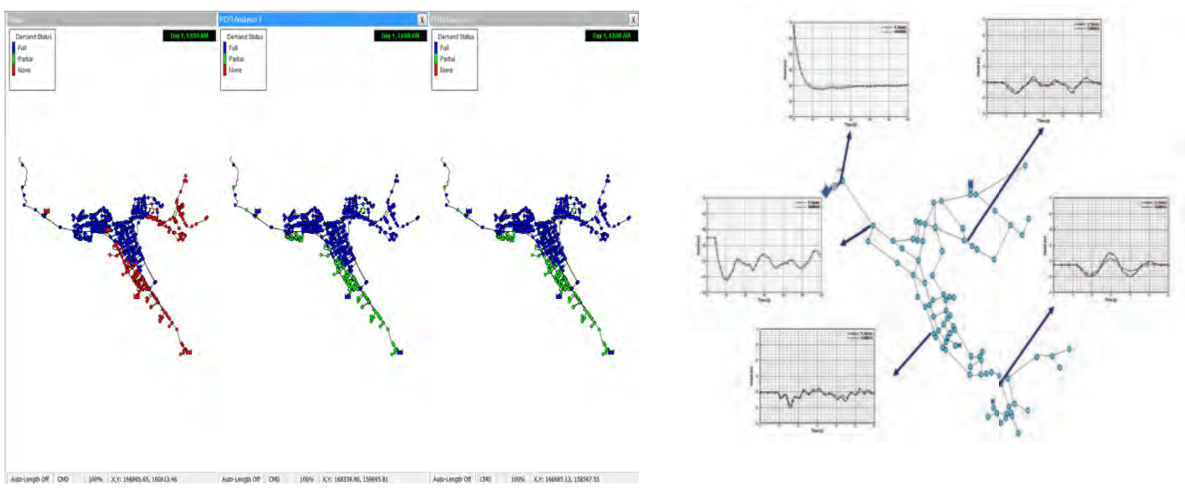
- (Objective) Objective of SWM is to gather a conspicuous amount of data and derive values from data to improve operations



[Turing Data into Values in SWM]

2.2 Smart Water Management (3)

- (Importance of solution & application) Water utilities should focus on the development smart solutions and applications with appropriate procedures, methods, techniques, and manuals



[Smart Solutions and Applications]

2.3 Characteristics of SWM (1)

- **(Characteristics) The characteristics of SWM may be indicators representing how much SWM is embedded in the water utilities' system**
  - Comprehensive data, automation, connectivity, real-time, and compatibility & interoperability are the main characteristics of SWM

01 **COMPREHENSIVE AND DETAILED DATA**

- Water utilities can obtain more comprehensive and complete data thro ugh digital technologies

02 **AUTOMATION**

- Water utilities can operate and control instrument and system automa tically with parameter setting

[Characteristics of SWM #1]

2.3 Characteristics of SWM (2)

03 **HYPER-CONNECTIVITY**

- Water utilities can change water management process in a systemwide manner through hyper-connectivity

04 **REAL-TIME**

- Water utilities can obtain real-time data and use them to monitor the performance, detect problems, and optimize the process

05 **SUPER-INTELLIGENCE**

- Water utilities can reconfigure business processes and increase efficie ncy based on the developments in AI, ML and robotics

[Characteristics of SWM #2]

2.4 SWM Implementation Groups

- (Solution development groups) System development with smart solutions in 3 separate groups is in place

Group	Company	Characteristics	Analysis Method
SM	• Itron • Neptune • Badger • Sensus • Aclara	• Customer-oriented • Quantity-oriented • Data management & reporting SW	• Data-driven analysis
Water Utility	• Suez • Veolia • K-water	• Operator-oriented • Quantity, quality, energy are considered	• Physical model analysis + Data-driven analysis
Smart City Management	• IBM • Oracle	• Customer-oriented • Electricity, gas, traffic are considered	• Data Driven analysis

3. Benefits of SWM

3.1 Benefits of SWM

3.1 Benefits of SWM

- **(Benefits) Water utilities can gains both direct economic value and indirect benefits in water resource management, water treatment, water distribution and customer service**

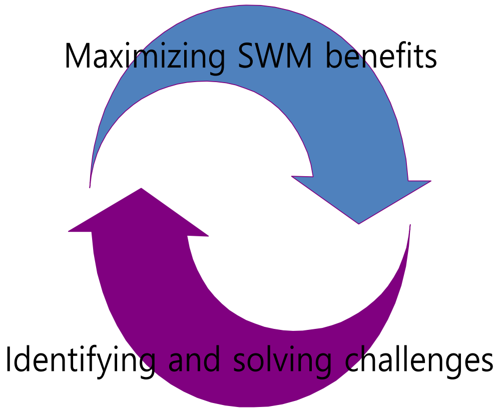
Benefits	Water resources	water treatment	Water distribution	Customer service	General
Direct economic values	- Understanding raw water characteristics - Labor savings	- Reduced chemical use - Energy efficiency - Reduced downtime	- Leakage reduction - Reduced labor costs - Network Optimization	- Billing - Reduced labor costs - Demand control	- Improving financials - Improving operations
Indirect benefits	- Understanding hydrological resources on a watershed level - Raw water quality	- Public health	- Water quality testing and alters - Predictive maintenance - Fewer disruptions to the public	- Improved customer experience and communication - Increased affordability	- Regulatory compliance - Increased resilience - Workforce development - Brand and innovation

4. Challenges in SWM Implementation

4.1 Challenges and Issues
4.2 Technical Challenges
4.3 Regulatory Challenges
4.4 Organizational Challenges
4.5 Partnership Challenges

4.1 Challenges and Issues

- (Benefits & Challenges) There are many discussions on the benefits of SWM so far, and from now on, we need to focus on the challenges in SWM implementation
- (Prerequisites) Without identifying and solving the challenges in SWM implementation pro-actively, adopting SWM may be a precipitous decision



[Two Main Objectives of SWM implementation]

4.1 Challenges and Issues

- (Challenges in SWM) Water utilities should recognize that there are technical, regulatory, organizational and partnerships challenges in the SWM application

Technical Challenges
- Different definitions & strategies on SWM
- Needs to integrate digital solution with tradition methods
- Lack of general SWM framework
- Big data management
- Application of data driven analysis
- Difficulty in project assessment

Regulatory Challenges
- Cybersecurity & privacy
- Inadequate traditional procurement process for SWM

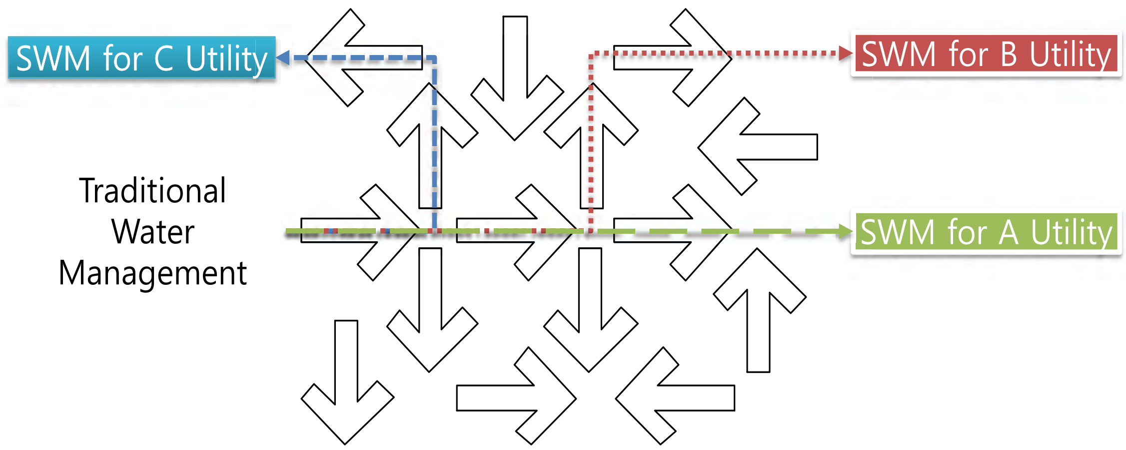
Organizational Challenges
- Internal resistance on SWM
- Various experts required

Partnerships Challenges
- Reducing gaps b/w providers and clients
- Gaps between water utilities
- High expectation from customers
- Lack of sufficient successful reference application

[Challenges in Implementing SWM]

4.2 Technical Challenges #1: Different Definition & Strategy

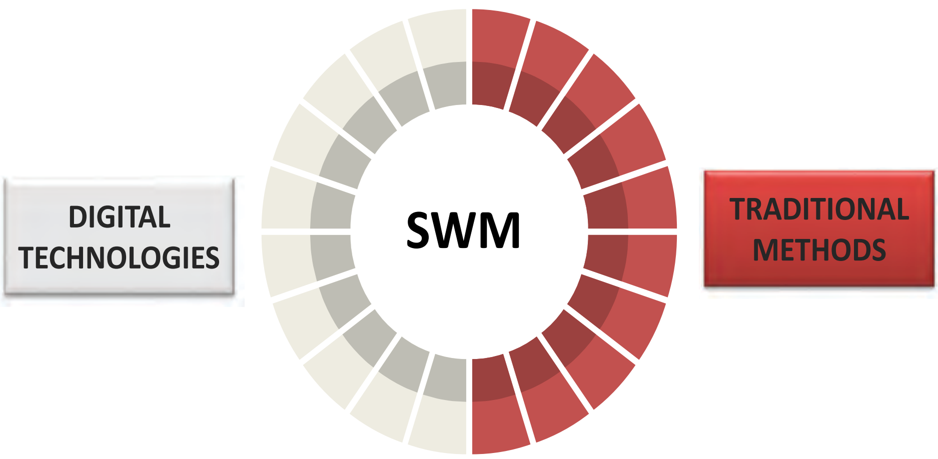
- (No consensus) The SWM concept is not uniform or clear, and its strategies have no common consensus
- (Customized plans) The purpose of the SWM pursued by each water utility is different, so each water utilities should develop their own strategies and action plans



[The Various Directions of SWM Pursued by Water Utilities]

4.2 Technical Challenges #2: Integration needed

- (Integration) It is needed to integrate digital technologies with traditional methods to create more values (e.g., reducing NRW, saving energy, improving water quality, real-time automatic controlling)



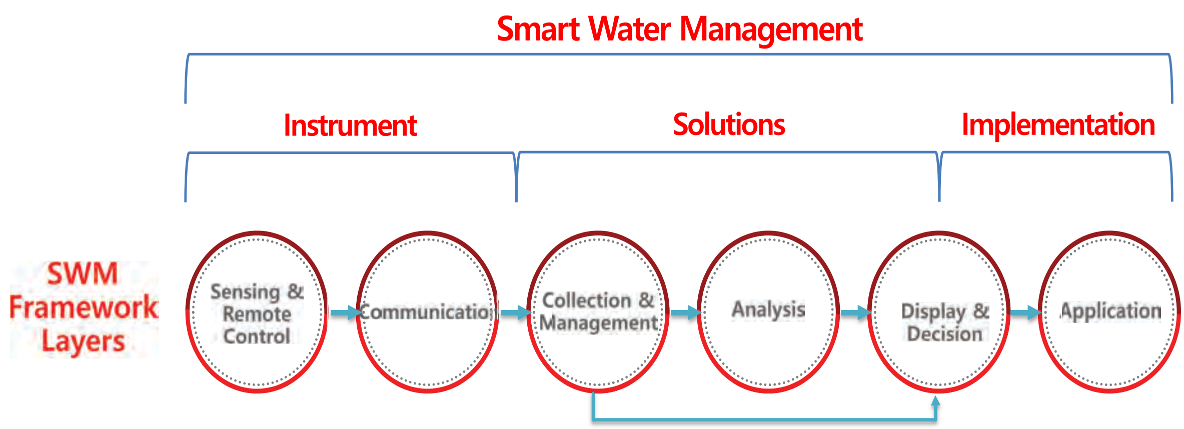
[Integration of Traditional Methods and Digital Technologies for Smart Water Management]

4.2 Technical Challenges #2: Integration needed

- (Facilitator) Digital technologies themselves are not solutions but facilitators by accessing more data and controlling automatically
- (Importance of capacity) It implies that if water utilities adopt digital technologies without capacity for traditional methods, these system will be demolished in a few years
- (Continuous integration) Digital technology is developing at a very rapid pace, so water utilities should do continuous integration.

4.2 Technical Challenges #3: Lack of General SWM framework

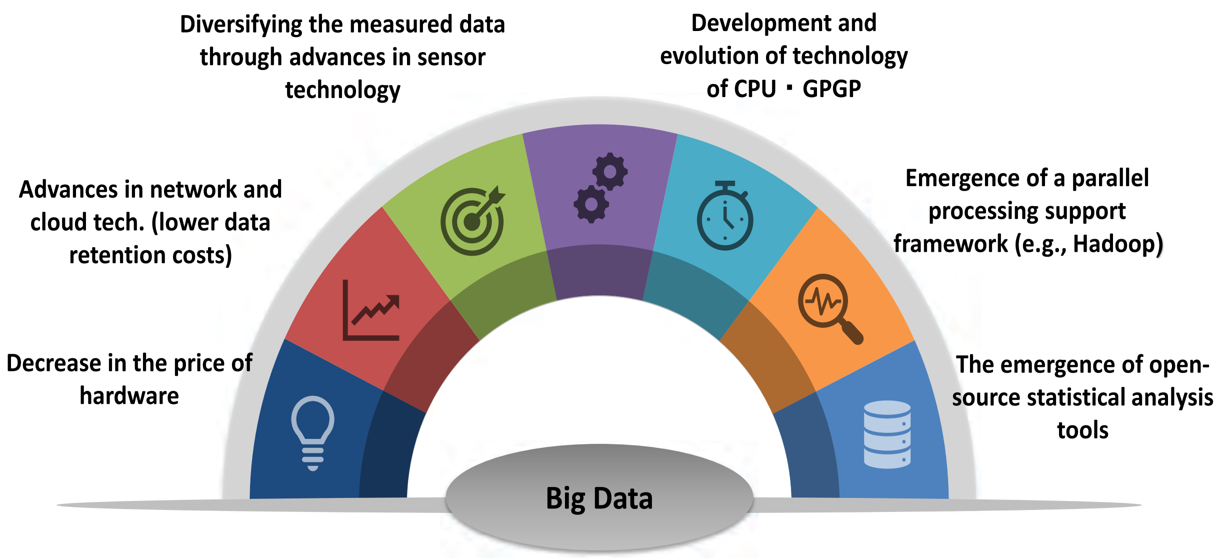
- (No single framework) There is no single SWM framework that can adequately suits all water utilities' situation
- (Problems) The lack of SWM framework prevents an effective interoperability and increases the cost and maintenance of such applications



[Smart Water Management Framework]

4.2 Technical Challenges #4: Big Data Management

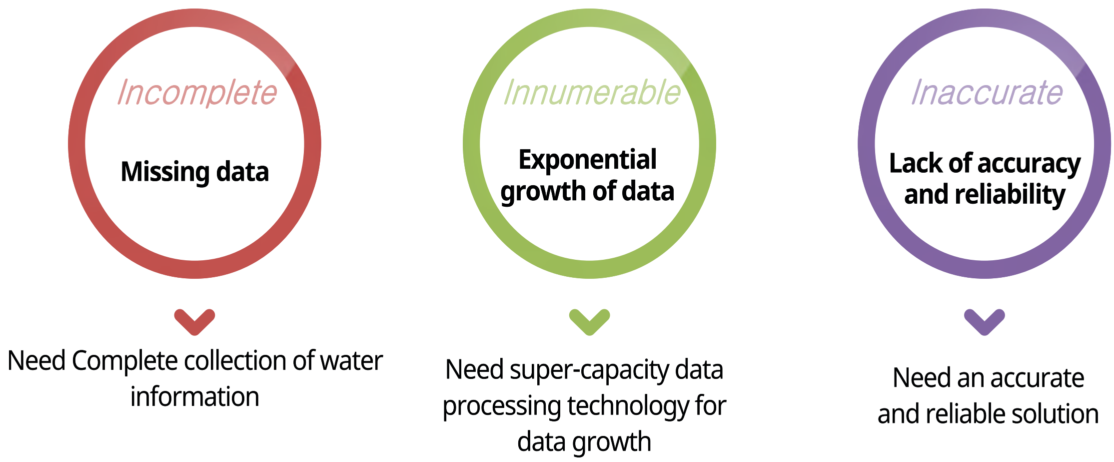
- (Big data) Technology advances in sensors, communication, computation, and data management have led to increased data acquisition in the water management sector



[The Reasons for the Occurence of Big Data]

4.2 Technical Challenges #4: Big Data Management

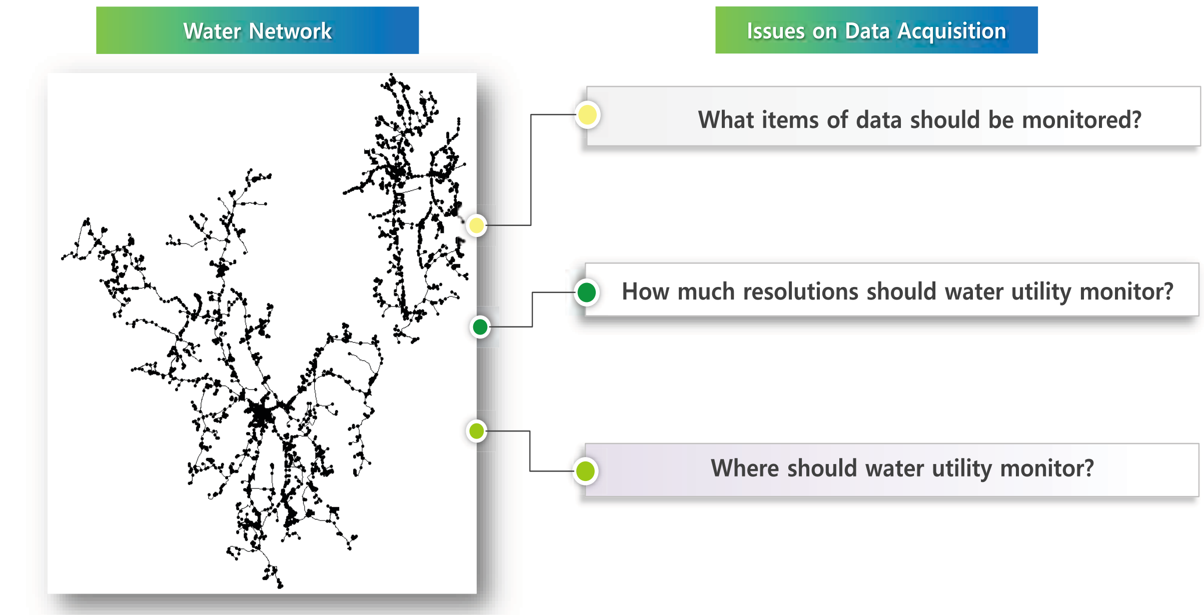
- (Raw data quality management) Issues related to raw data such as data incompletion, innumerable data, data inaccuracy should be handled for successful and efficient data-driven analysis



[Problems with data collection]

4.2 Technical Challenges #4: Big Data Management

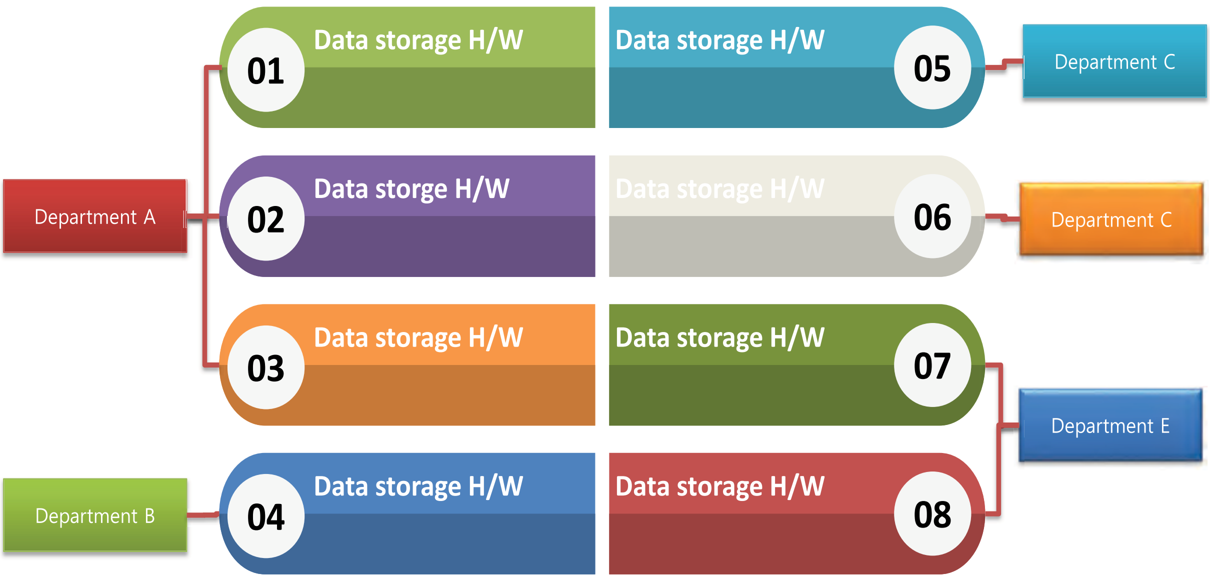
- (Data acquisition) Water utilities need to make decisions about which data to collect at what resolution and at what point for analysis purposes



[Issues on Data Acquisition]

4.2 Technical Challenges #4: Big Data Management

- (Data silo) Data silo, raw data which can be only accessed by one department and isolated from the rest departments, culminated in a lack of transparency, efficiency, and trust on the data



[Limited Data Access in One Organization]

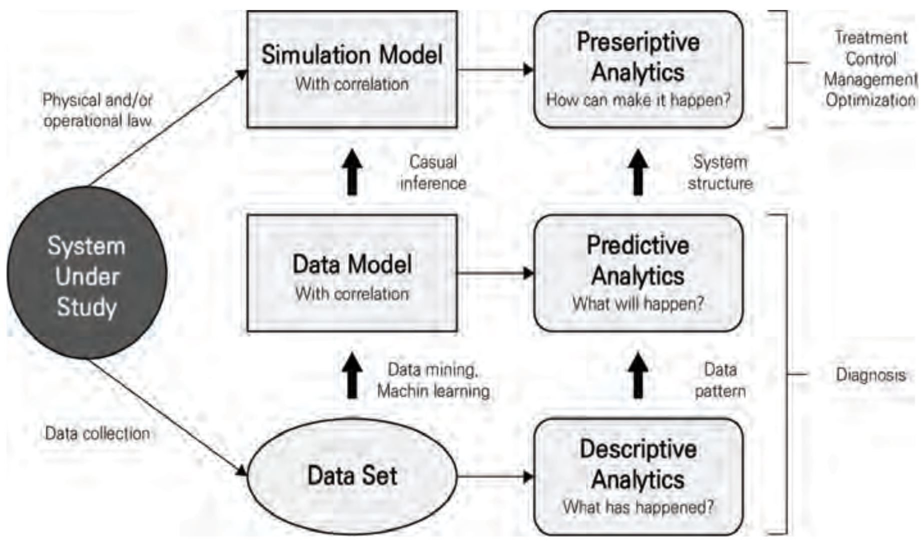
4.2 Technical Challenges #5: Lack of Analysis Guidelines

- (lack of capacity) Much of the existing utilities do not have the technical understanding of what analytic methodologies should be used to most accurately understand the story the data is telling

[Data Rich but Information Poverty Situation in Smart Water Management]

4.2 Technical Challenges #5: Lack of Analysis Guidelines

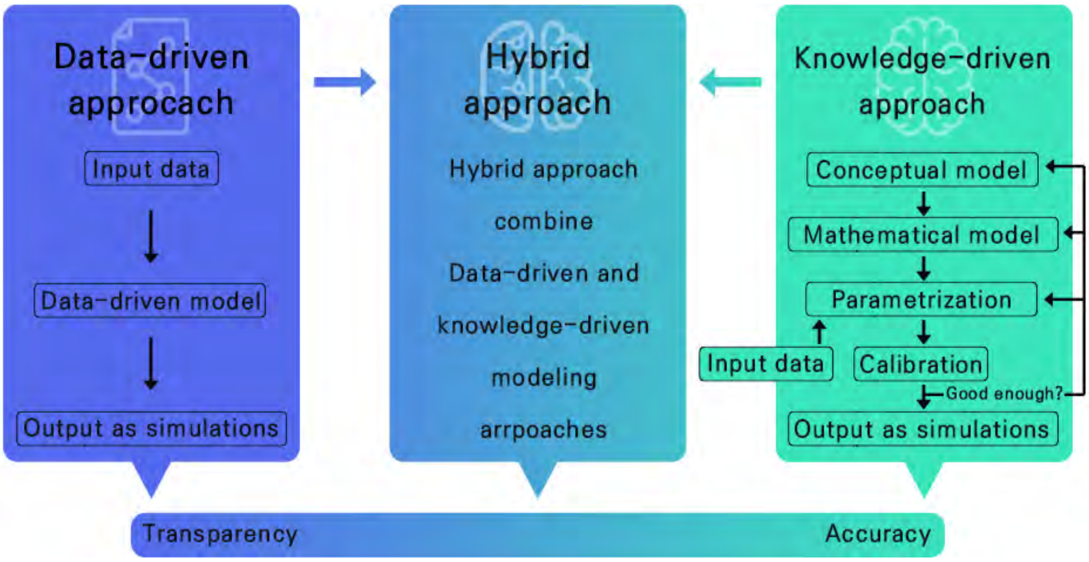
- (Increasing data-driven analysis) Increased data increases the need and possibility of data-driven analysis in the field of integrated water management



[The Role of Physical and Data-driven Models for System Analysis]

4.2 Technical Challenges #5: Lack of Analysis Guidelines

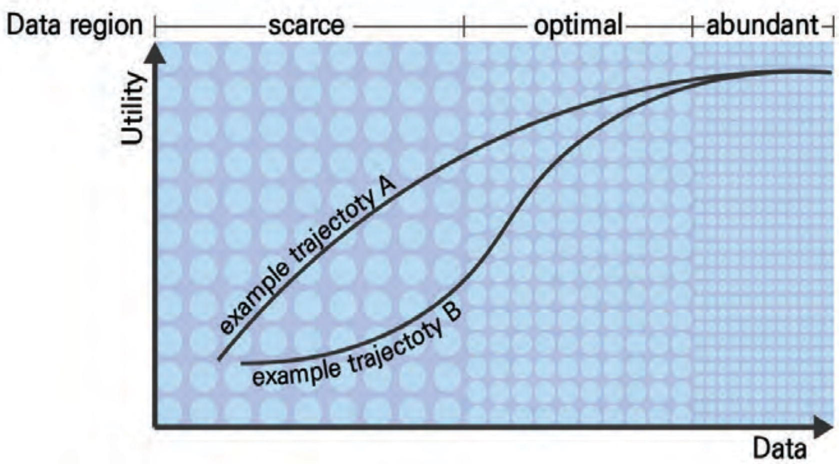
- (Hybrid analysis) The integration of physical and data-driven models (typically a combination of numerical and statistical models) can improve the accuracy and reliability of interpretations



[Comparison schematic of data-driven models, hybrid models, and physical models]

4.2 Technical Challenges #5: Lack of Analysis Guidelines

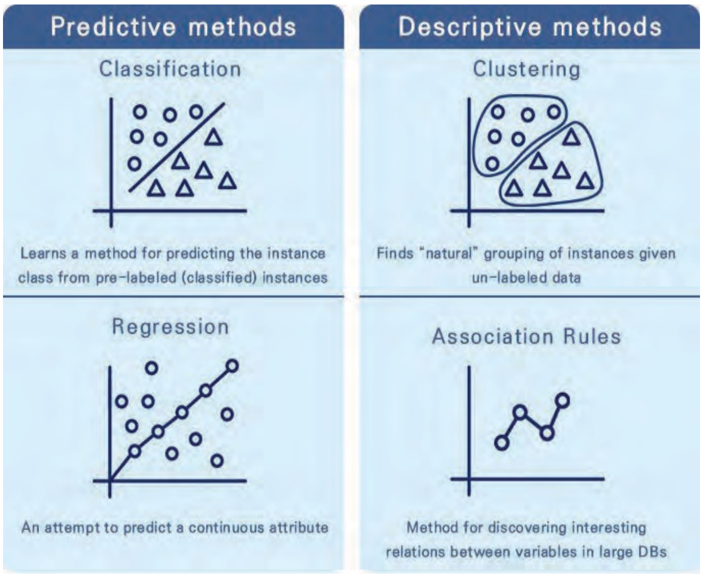
- (Analysis Guidelines) Data-driven analysis guidelines considering task discovery, selection, analysis methodology, and field application are not well established



[Correlation of Utility and Data Amount]

4.2 Technical Challenges #5: Lack of Analysis Guidelines

- (Analysis Algorithm) Choosing a fit algorithm without data overfitting and underfitting issues is important



[The Main Purpose of Analysis Techniques]

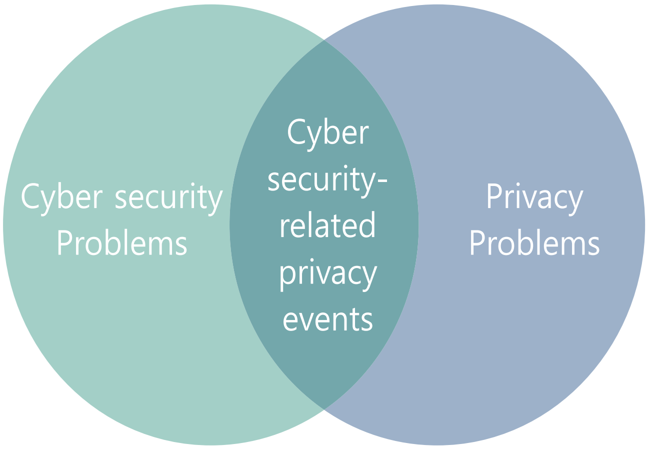
4.2 Technical Challenges #6: Difficulty in Assessment

- (Difficulty in assessment) It is very difficult to accurately evaluate the costs and benefits incurred when conducting SWM projects

[General Assessment Process in Water Management]

4.3 Regulatory Challenges #1: Cyber security & privacy

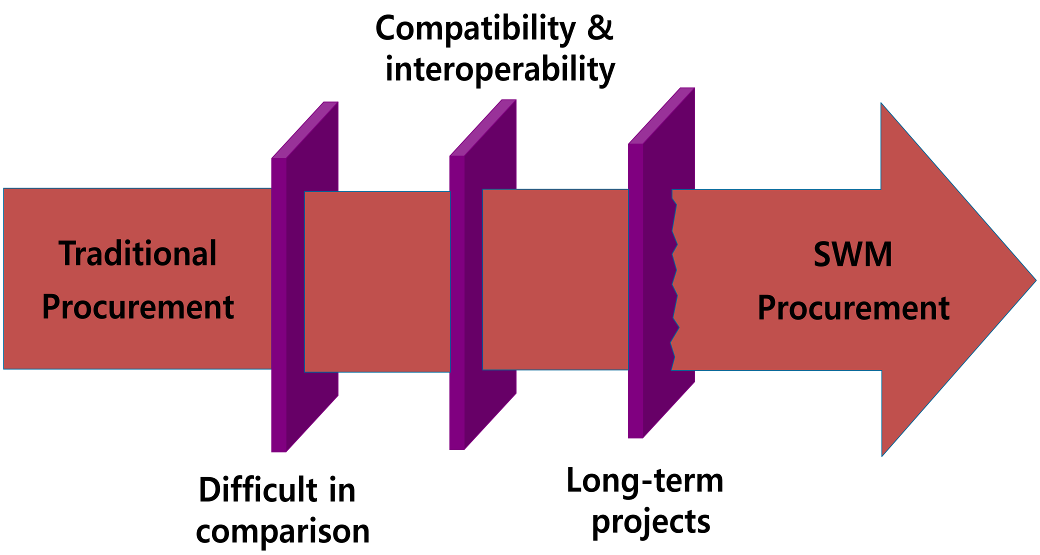
- (Cyber security) The increased connectivity and automation without considering data authenticity and reliability would lead to cyber security issues
- (Privacy) Water utilities now confront increased availability of personal information and potential for abuse by internal employees or third parties



[Cyber Security and Privacy Problems in SWM]

4.3 Regulatory Challenges #2: Inadequate Procurement

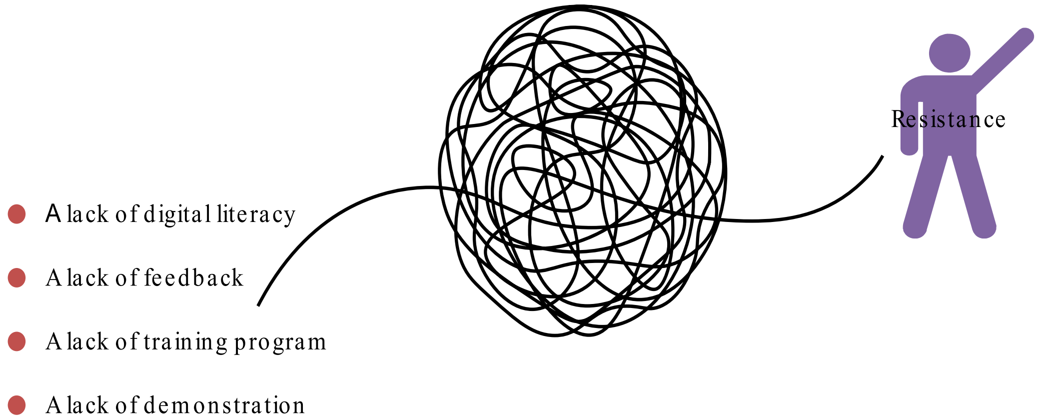
- (Inadequate procurement) Most utilities have to buy through public tenders and this does not work well for SWM projects



[Barriers in SWM Procurement]

4.4 Organizational Challenges #1: Internal Resistance

- (Internal resistance) Adopting new ways of management can lead to concerns to skill obsolescence, workforce transition, change management and job insecurity



[Staff Resistance in Implementing Smart Water Management]

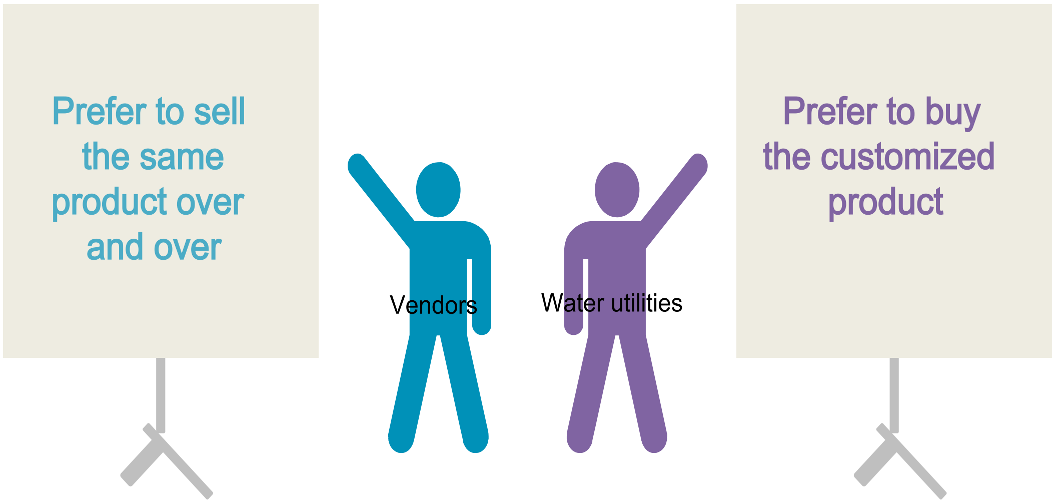
4.4 Organizational Challenges #2: Various Experts Required

- (Various experts) Efficient data-based interpretation requires the involvement of data scientists, algorithmic experts, decision makers, domain experts, visualization experts, and tool developers

[Necessary Techniques for Data-driven Analysis]

4.5 Partnership Challenges #1: High gap b/w providers and clients

- (Mismatch) In some cases, the product that the vendor wants to sell is different from the product that the water utility needs



[The Gap between What the Vendor Wants to Sell and What the Water Utility Want to Buy]

4.5 Partnership Challenges #2: Different Capacity & Situation

- (Different capacity and situation) Because each water utility had different capacity and is in different situation, each had a difference in the effort required to succeed in SWM

[Different Starting Point in Implementing SWM]

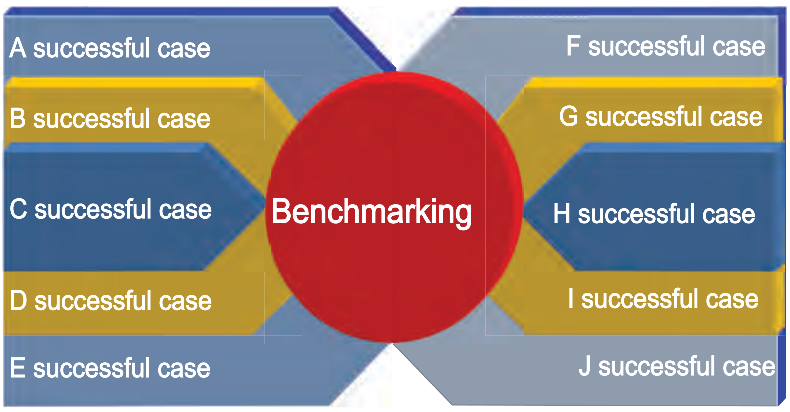
4.5 Partnership Challenges #3: High expectation from customer

- (High expectation) Customers have experienced digital innovation in other fields, so they demand a high level of service from water utilities

[Customers' High Expectation from SWM]

4.5 Partnership Challenges #4: Lack of Benchmarking Cases

- (Limited successful cases) There are not many successful SWM cases that water utilities can benchmarking and the procedures and processes of success projects are not clearly shared.



[Benchmarking based on Several Successful Cases]


Thank you very much

SWM Strategies and Activities

Smart Water Management


2. SWM Strategies and Activities
United Nations Educational, Scientific and Cultural Organization
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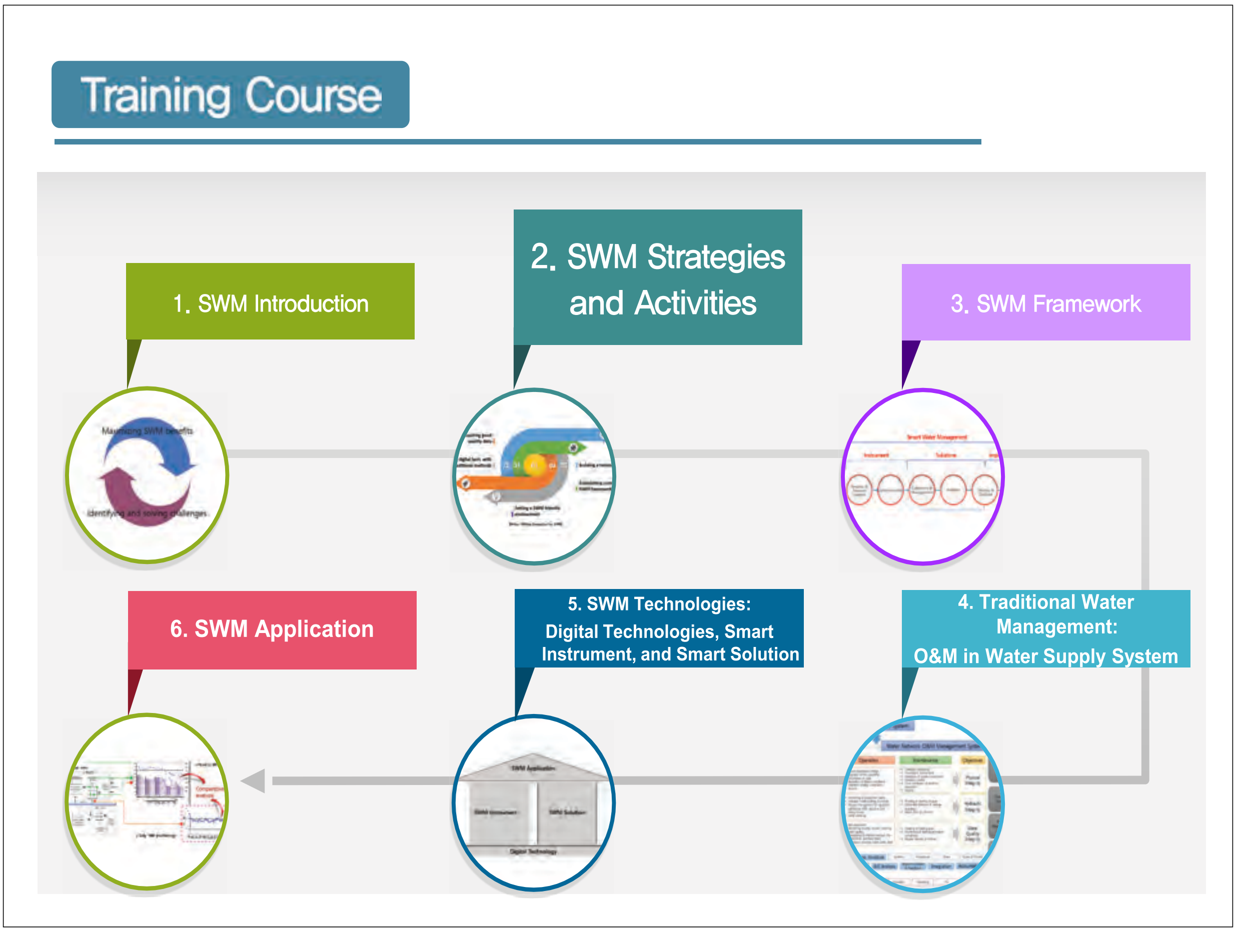
International Centre for Water Security and Sustainable Management


Training Course
1. SWM Introduction
2. SWM Strategies and Activities
3. SWM Framework
4. Traditional Water Management: O&M in Water Supply System
5. SWM Technologies: Digital Technologies, Smart Instrument, and Smart Solution
6. SWM Application

Aims & Objectives

- The aims of the course are to:

(1) Provide SWM implementation phase, SWM strategies, and various activities according to the directions of the SWM strategies;

(2) Enable trainees to establish their SWM strategies and select appropriate activities in SWM implementation

- The objectives are that trainees will understand:

(1) Three-phase of SWM implementation;

(2) One basic strategy and four implementation strategies

(3) Activities related to strategies

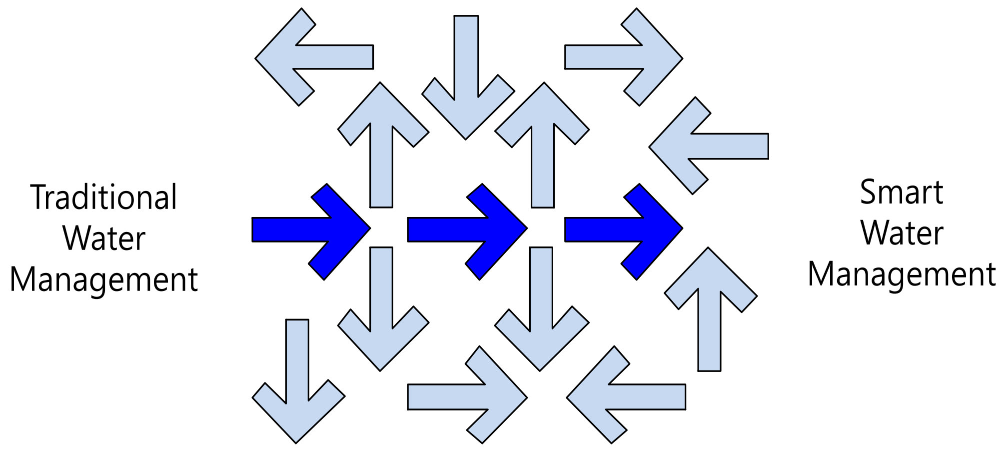
Contents

1. Overview
2. SWM Phase
3. Strategies for SWM
4. Setting a SWM Friendly Environment
5. Building a Holistic SWM Roadmap
6. Establishing and Implementing SWM Framework
7. Acquiring Good Quality Data
8. Integrating Digital Technology with Tradition Methods
9. SWM Project Implementation

1. Overview

1.1 Backgrounds (1)

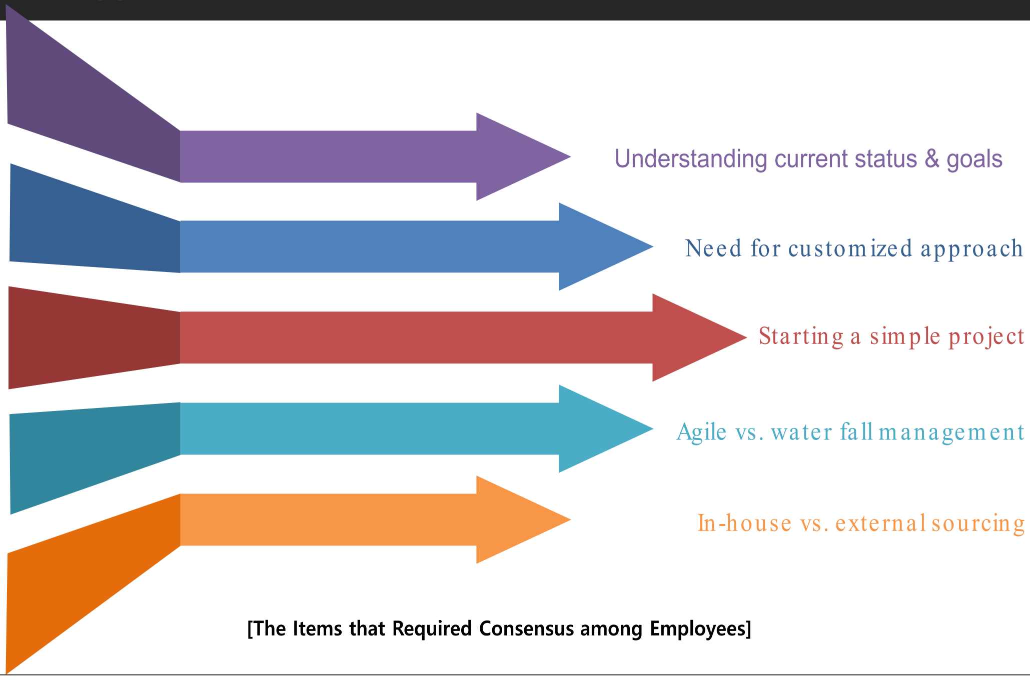
- (No standard) The sound strategies are needed to succeed in SWM implementation; however, there is no standard for SWM journey



[No Generalized Standard for SWM Journey]

1.1 Backgrounds (2)

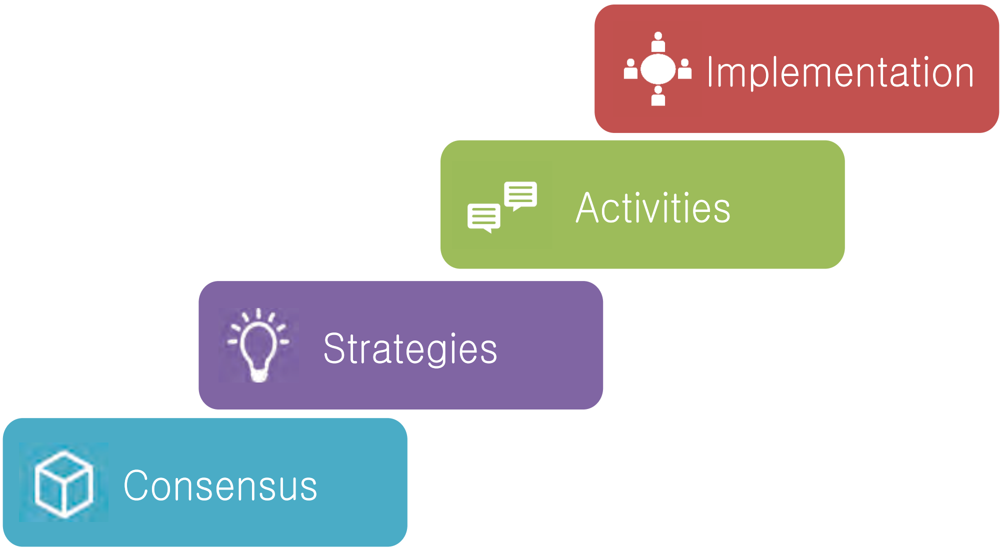
- (Stace on SWM) Before launching SWM, water utilities need to elucidate their stance in various aspects and build the consensus among employees for SWM applications



[The Items that Required Consensus among Employees]

1.1 Backgrounds (3)

- (Strategies and implementation) Strategies and activities shall be established after consensus is formed, and SWM shall be implemented accordingly.



[Hierarchy on SWM Consensus, Strategies, Activities, and Implementation]

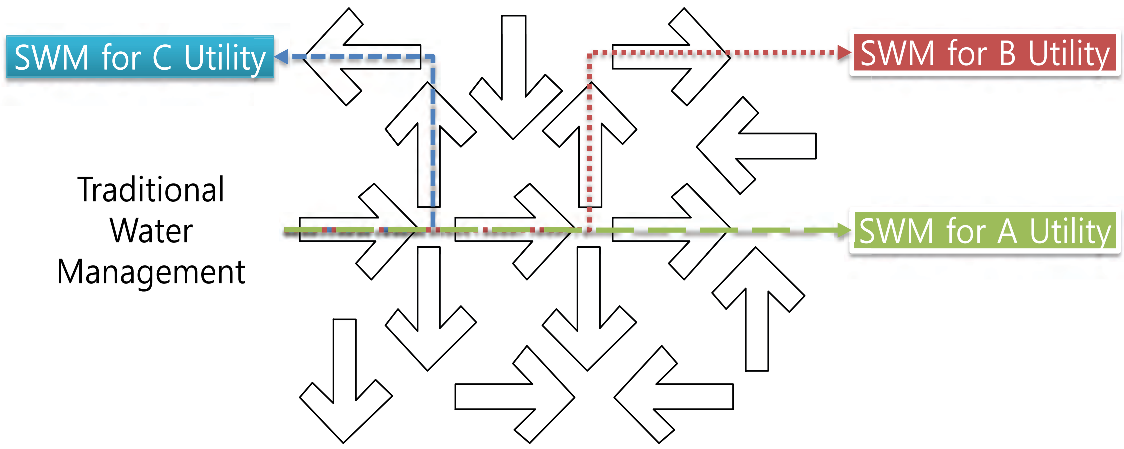
1.2 Understanding Current Status & Level

- (Status & level) Water utilities need to understand their current O&M capabilities and the levels of maturity in adopting SWM

[The Current Position of Each Water Utility at the Stage of Success]

1.3 Setting up Suitable SWM Goals

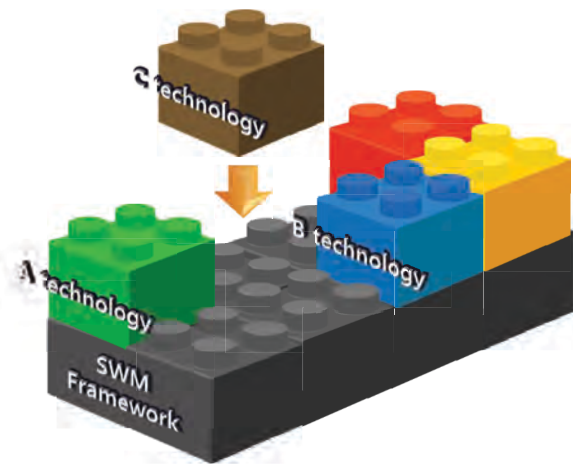
- (Different suitable goals) Water utilities should derive their own goals in SWM because different water utilities are subject to various contexts such as a lack of water resources, aging infrastructure, high NRW, and regulations



[The Various Directions of SWM Pursued by Water Utilities]

1.4 Customized and Tailored Approach

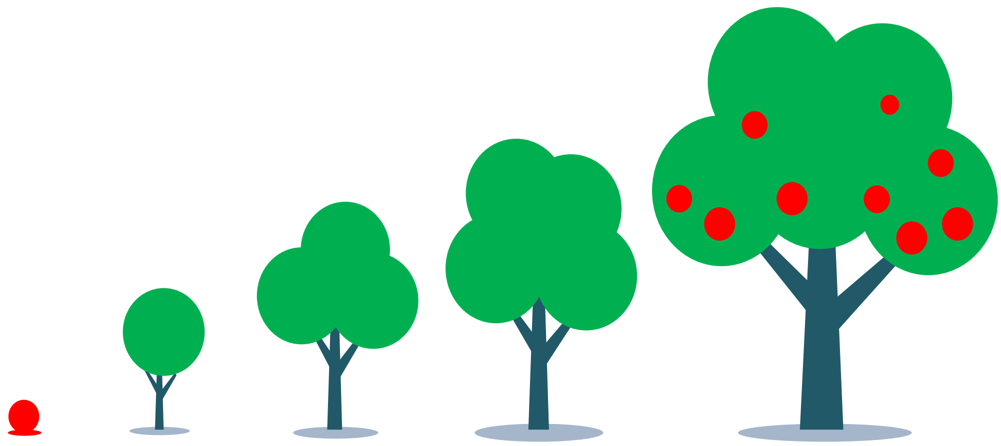
- (Customized approach) Water utilities should tailor and customize their adoption and application of digital technologies according to their established objectives



[The Tailored and Customized SWM Approach]

1.5 Starting a Simple Project

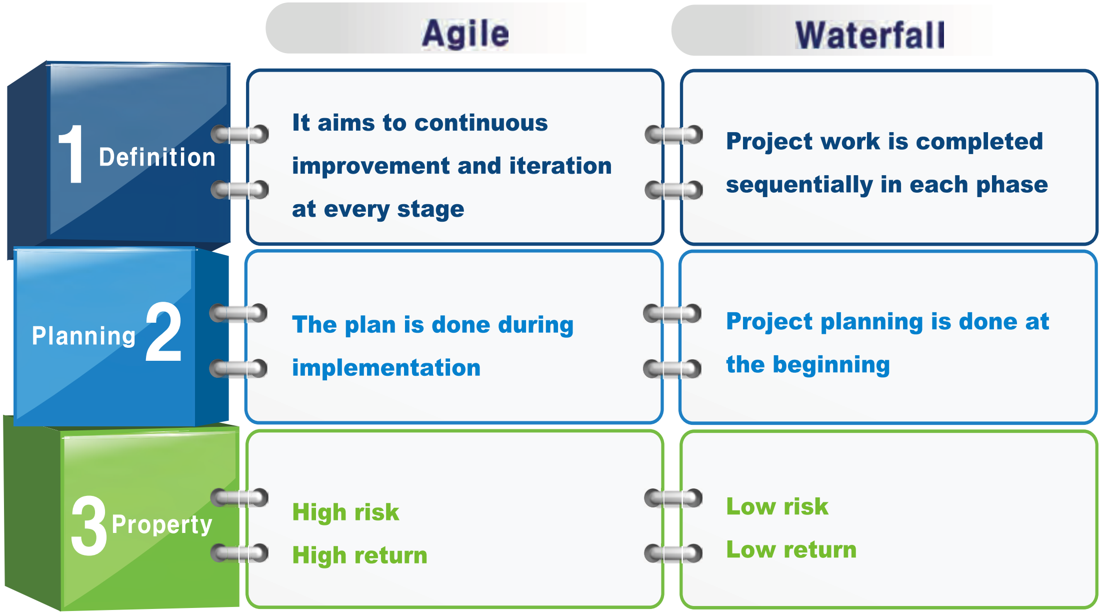
- (Simple project) Rather than implementing a complex and complete project at the beginning stage, expanding SWM through small success stories is the way to succeed in SWM



[From Simple Pilot SWM Project to Full SWM Project]

1.6 Project Management: Agile vs. Waterfall

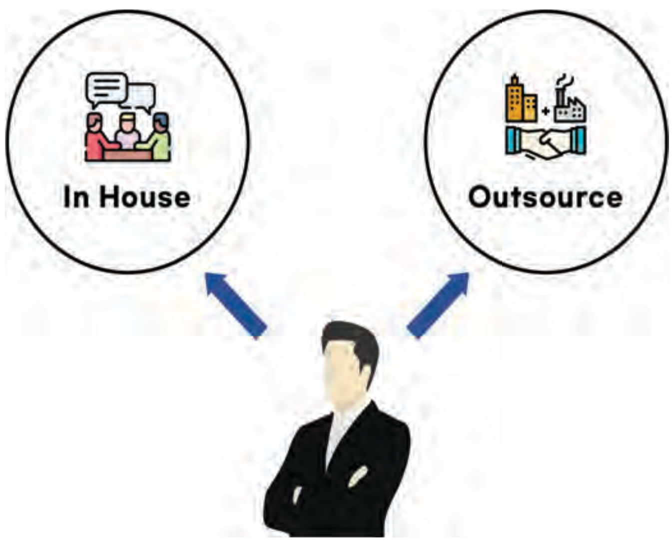
- (Project management) Appropriate SWM project management approach should be selected among agile and waterfall approach



[Characteristics of Agile and Waterfall Approach]

1.7 Solution Sourcing: In-house vs. Outsource

- (Sourcing) Water utilities should determine their SWM solution sourcing among in-house development and vender outsource



[Two approach for Solution Sourcing]

2. SWM Phase

2.1 SWM Phase

- **(SWM phase) Water utilities applying SWM are belong to one of the phases of developing, data-oriented, and integration moments**

Data-oriented moment

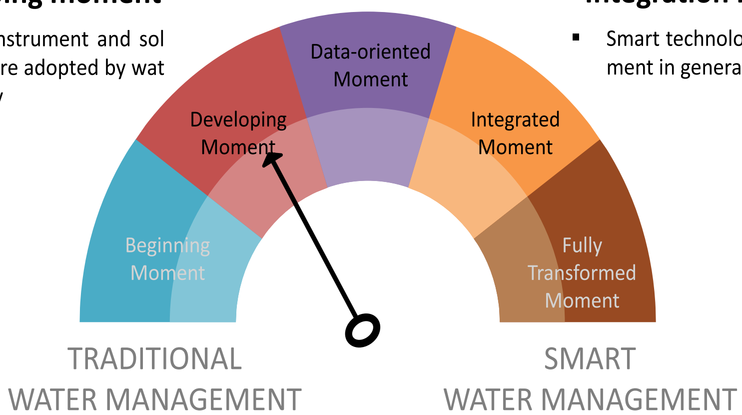
- Acquired data are used to derive some insight

Developing moment

- Smart instrument and solutions are adopted by water utility

Integration moment

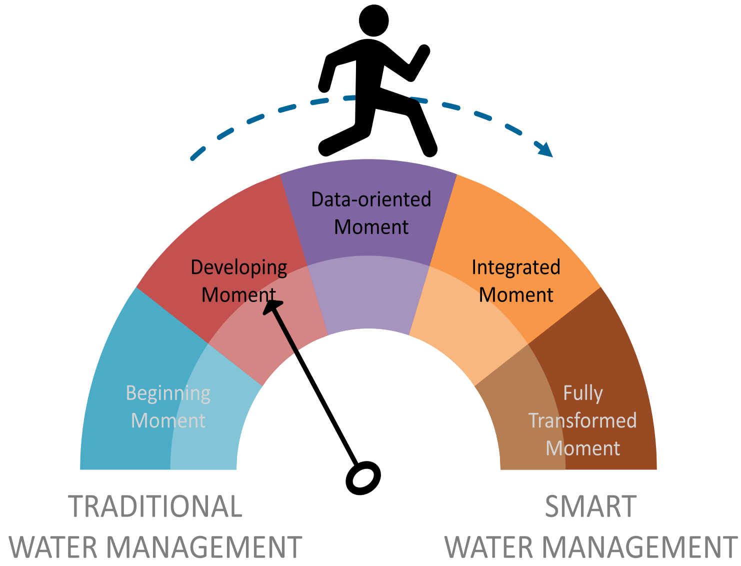
- Smart technologies are implement in general O&M



[SWM Implementation Phase]

2.1 SWM Phase

- (Means for assessment) By understanding their current status in SWM phase, water utilities can set a general path for their transformation to make use of smart technologies and break through the traditional concept



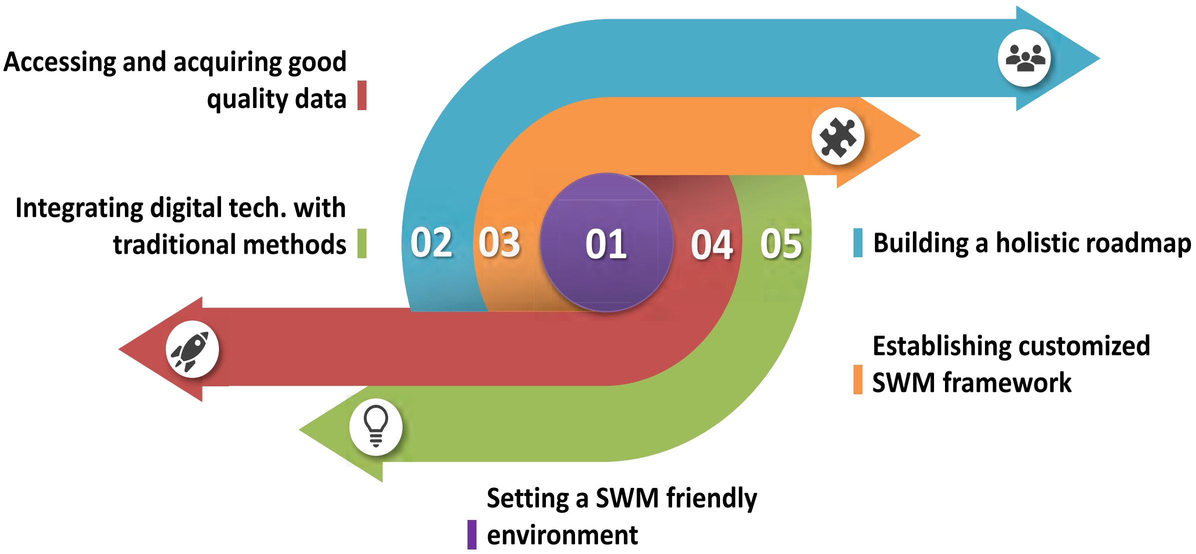
[SWM Implementation Phase]

3. Strategies for SWM

3.1 Strategies for SWM
3.2 Activities for SWM

3.1 Strategies for SWM (1)

- (Strategies) The SWM strategy consists of one basic strategy and four implementation strategies



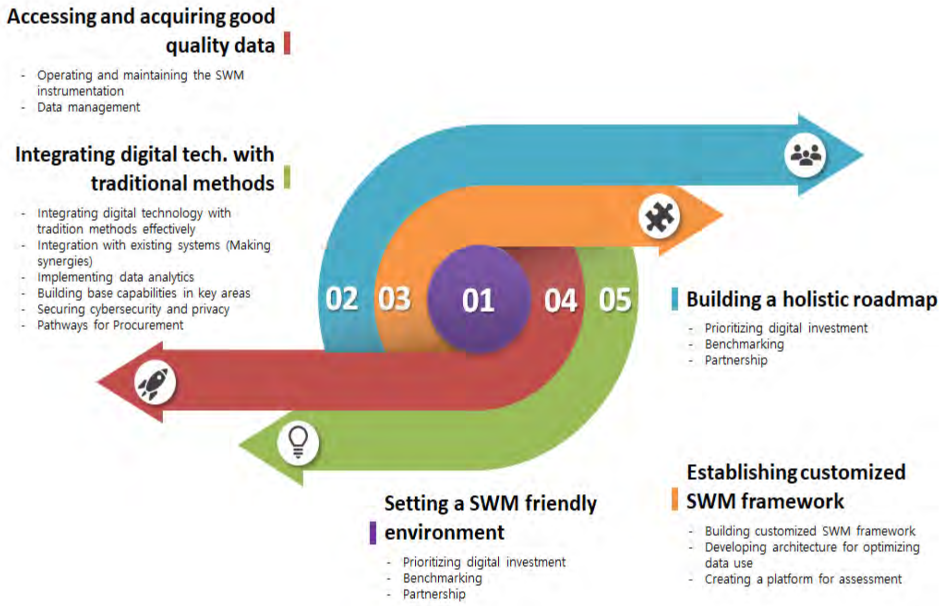
[Water Utilities Strategies for SWM]

3.1 Strategies for SWM (2)

- (Setting environment) SWM friendly environment is needed to initiate and participate the paradigm shift and reduce resistance to the introduction of digital technologies
- (SWM roadmap) A holistic SWM roadmap enable water utilities to set an appropriate path while identifying the overarching activities to accelerate the SWM implementation
- (Framework) Water utilities should build a systematic and customized SWM framework to guide and accelerate the implementation of SWM
- (Good data) Water utilities should collect relevant and good quality data for their data scientists and domain experts to use
- (Integration) SWM is not adopting and implementing digital technologies, it is about getting the value by integrating digital technologies and tradition methods

3.2 SWM Activities

- (Activities) Water utilities should perform various activities according to the direction of the SWM strategies



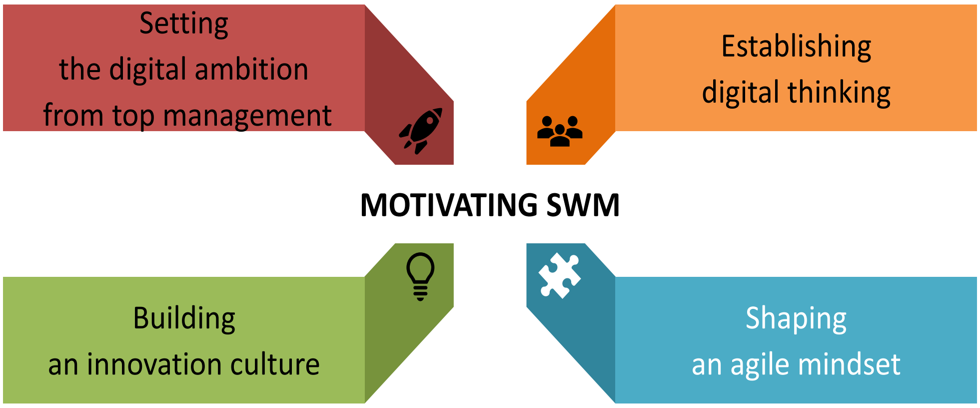
[Water Utilities Activities for SWM]

4. Setting a SWM Friendly Environment

4.1 Motivating and Initiating SWM
4.2 Addressing staff resistance
4.3 Starting a Simple Project

4.1 Motivating and Initiating SWM

- **(SWM Motivation) Water utilities should be motivated for digital adoption to apply SWM easily and quickly**



[Objectives of Motivating SWM]

4.2 Addressing staff resistance

- **(Addressing resistance) Water utilities should mitigate and address staff resistance with a long-term, well structured, and human-oriented process**

01 Human-centered SWM implementation

02 Running training and education programs

03 Building cross-functional and agile teams

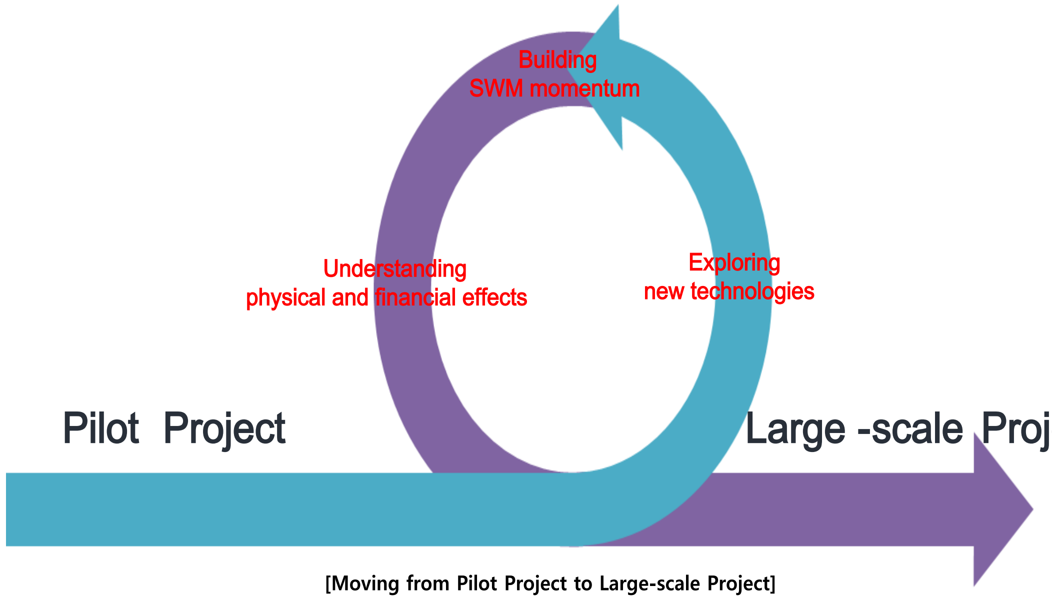
05 Encouraging cooperation between young and mature workforce

06 Gathering opinion and providing feedback

[Programs for Addressing Staff Resistance]

4.3 Starting a Simple Project

- (Result-synergy) Simple successive projects will help shape the momentum for shifting to SWM by offering a means to explore technologies and enable further big projects



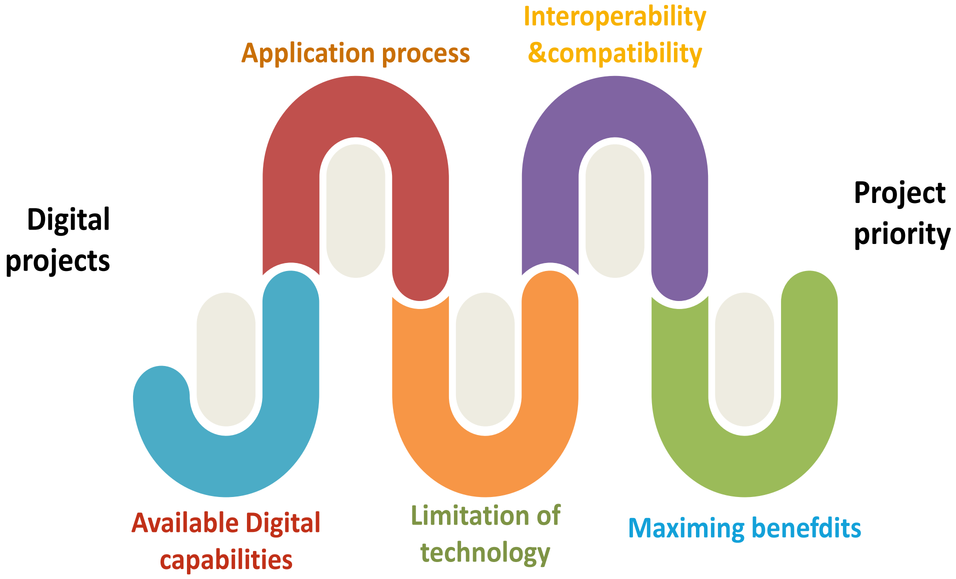
[Moving from Pilot Project to Large-scale Project]

5. Building a Holistic SWM Roadmap

5.1 Prioritizing digital investment
5.2 Benchmarking
5.3 Utility-to-Utility Partnership

5.1 Prioritizing digital investment

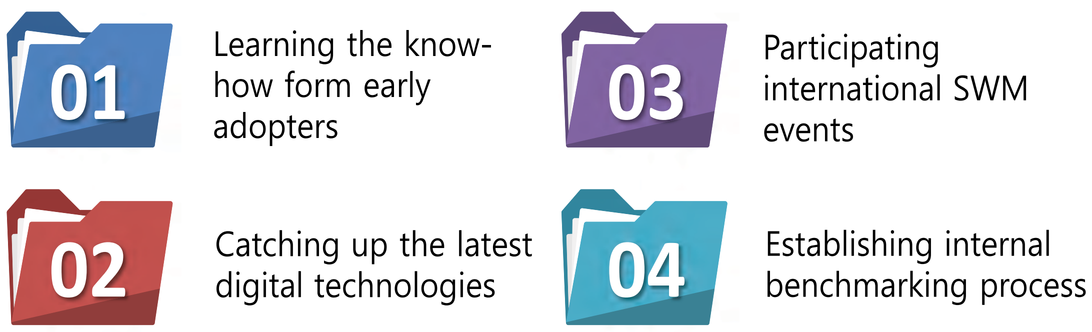
- (Investment priority) Choosing the right combination of investment and setting the reasonable priorities are crucial by considering who to derive values



[Considering Factors for Prioritizing the Digital Projects]

5.2 Benchmarking

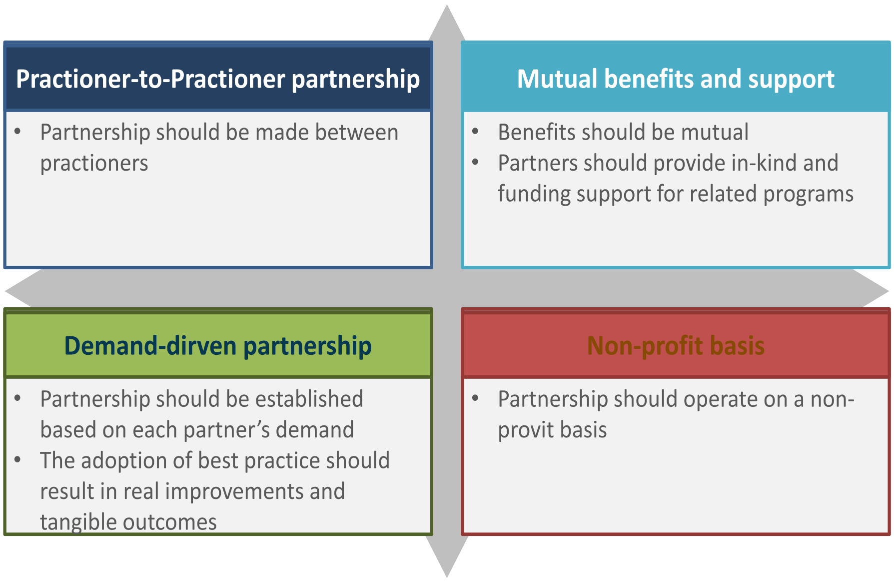
- (Benchmarking) Water utilities should dialogue and benchmark the early adopters to capture the SWM implementation experience and build a body of knowledge that motivate and inspire internal staff



[Programs for Benchmarking]

5.3 Utility-to-Utility Partnership

- (Utility-to-utility partnership) Water utilities focus on sustained exchange between practitioners in promoting the SWM adoption, sharing best practices, and building human and utilities' capacity



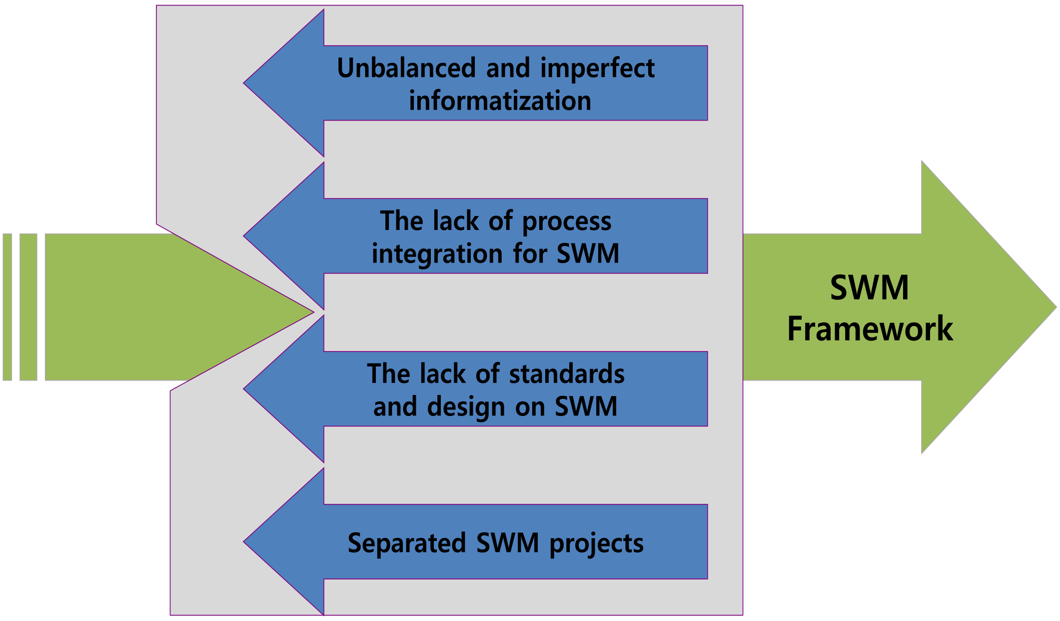
[Principles for Utility-to-Utility Partnership]

6. Establishing and Implementing SWM Framework

6.1 Building Customized SWM Framework
6.2 Developing Architecture for Optimizing Data Use
6.3 Creating a Platform for Assessment

6.1 Building Customized SWM Framework

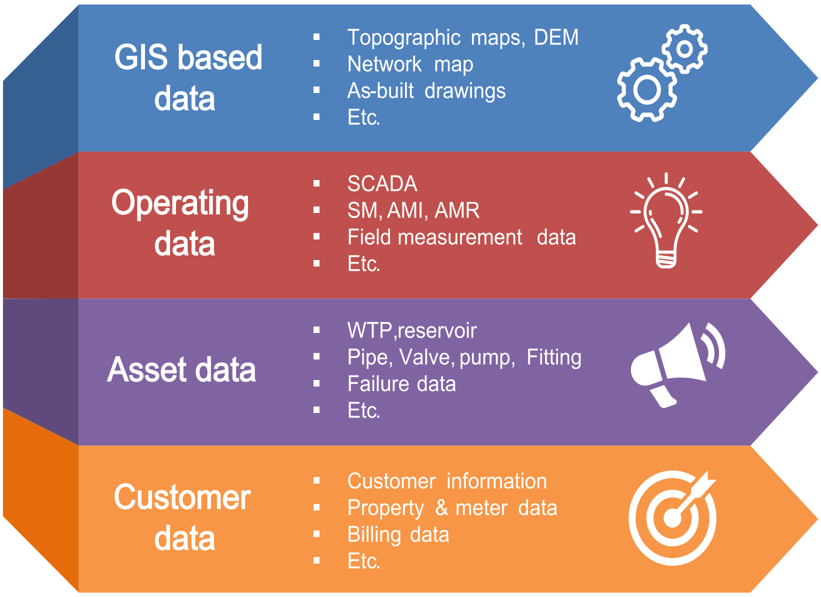
- (Clear framework) Water utilities should build a systematic SWM framework to overcome the lack of planning and accelerate the SWM implementation



[SWM Framework to Overcome Adoption Resistance]

6.2 Developing Architecture for Optimizing Data Use

- (Data structure optimization) Water utilities should optimize the data structure by breaking down information silos and extract value from it

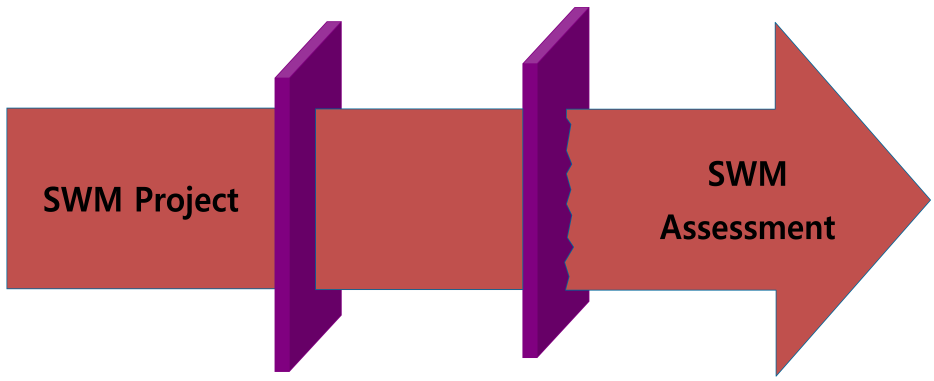


[Water Utilities' Main Data Group]

6.3 Creating a platform for assessment

- (Assessment) Water utilities should quantify and asses third SWM projects using tools or assessment matrix even though it is challenging due to lack of assessment tool and no consensus on measuring return on investment

Lack of assessment tools



No consensus on how to measure benefits and costs

[Barriers in SWM Project Assessment]

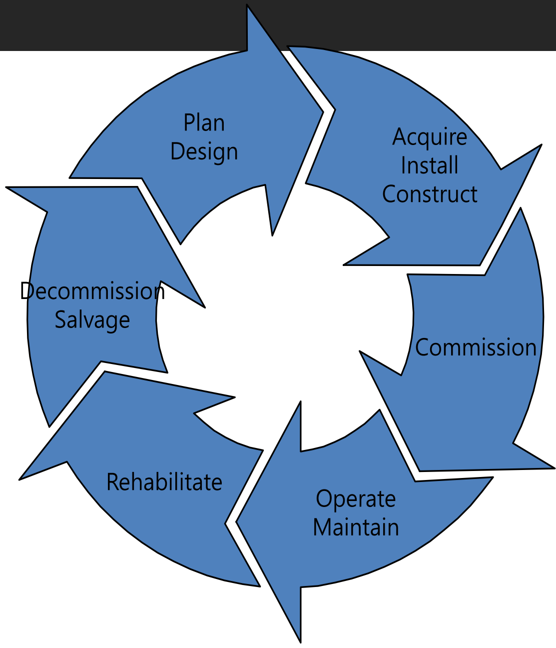
7. Acquiring Good Quality Data

7.1 Installing, Operating and Maintaining SWM Instrumentation

7.2 Data Management

7.1 Installing, Operating and Maintaining SWM Instrumentation

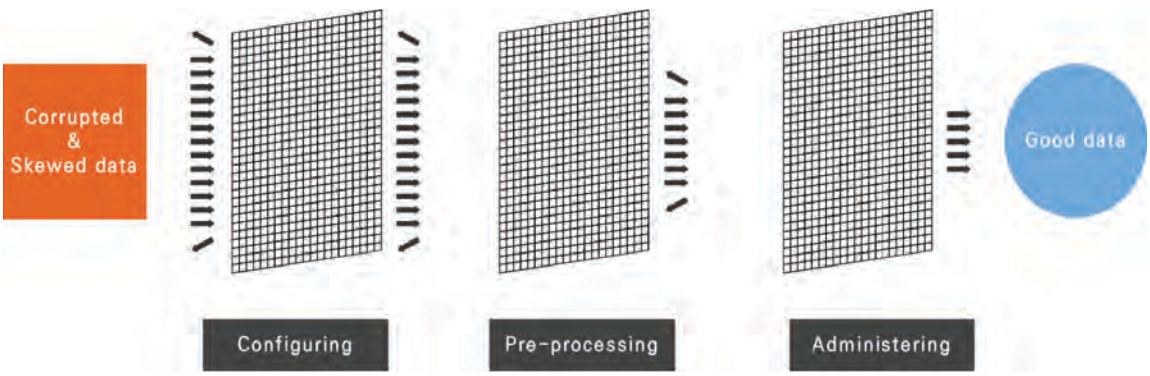
- (SWM instrument) Most of the instrument applied to SWM are mechanical and electronic device, so new operation and management guidelines should be established



[Life cycle of SWM Instrument]

7.2 Data Management (1)

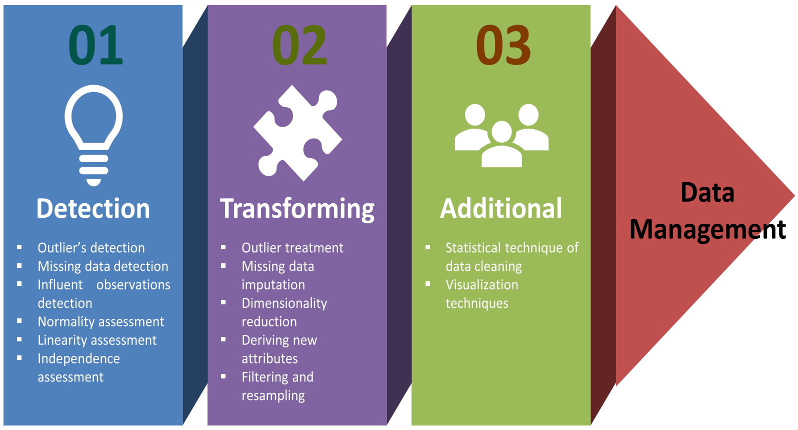
- (Data management) Since raw data have data corruption (e.g., missing and fault data) and data skew (e.g., unsynchronized data), water utilities should manage raw data to yield high-performance data mining



[Data Management to Yield High-performance Data Mining]

7.2 Data Management (2)

- (Techniques for data management) Detection techniques for detection imperfections in data sets, transforming techniques for obtaining more manageable data sets, and additional techniques are used for data preprocessing.



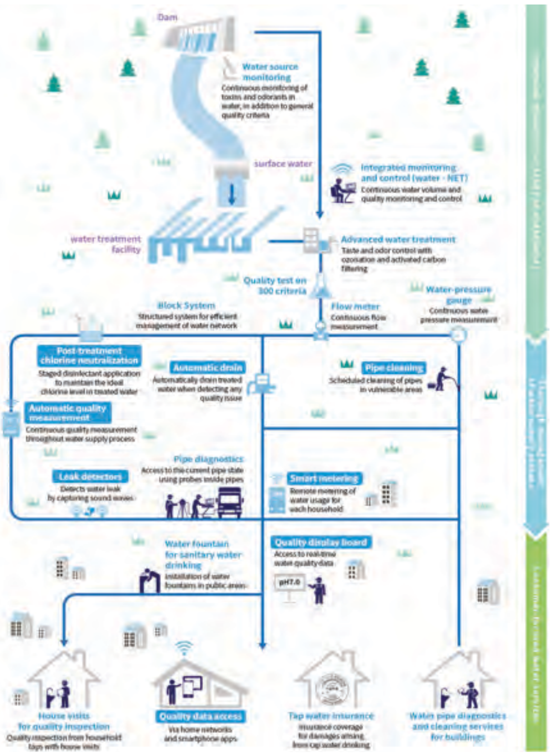
[Implemented Techniques for Data Management]

8. Integrating Digital Technology with Tradition Methods

8.1 Integration Digital Technologies with Existing Systems
8.2 Implementing Data Analytics
8.3 Building Base Capabilities in Key Areas
8.4 Securing Cybersecurity
8.5 Modifying Pathways for Procurement

8.1 Integration Digital Technologies with Existing Systems

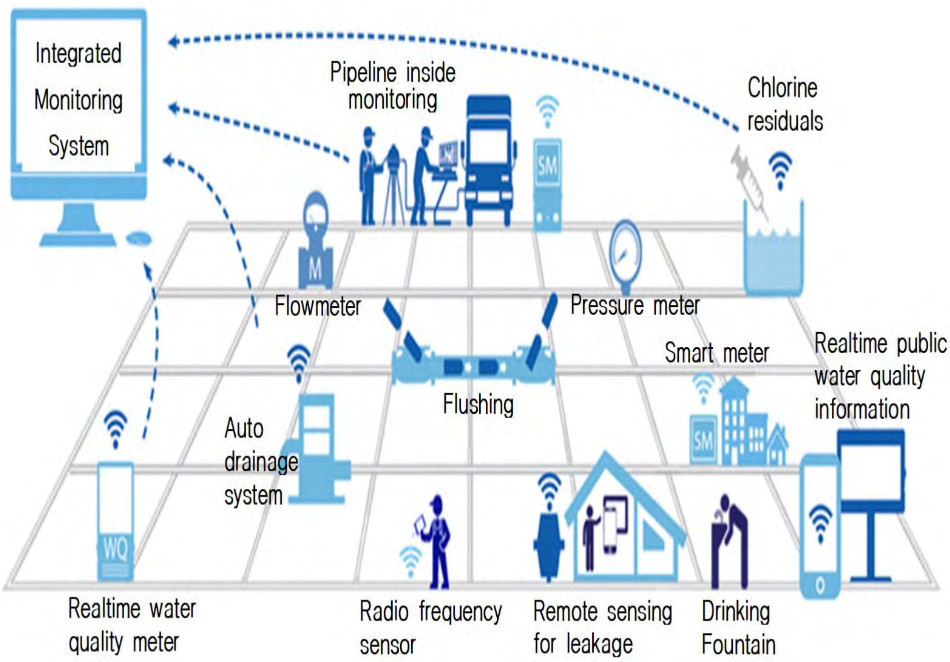
- (Making synergies) Digital technologies can be integrated with traditional methods at any key point in urban water cycle
- (Compatibility) Compatibility and interoperability should be considered in integration process
- (Traditional methods) Water utilities should be adroit at operating and maintaining with classic methods



[Implemented Digital Technologies in Urban Water System]

Source : K-water

8.1 Integration Digital Technologies with Existing Systems

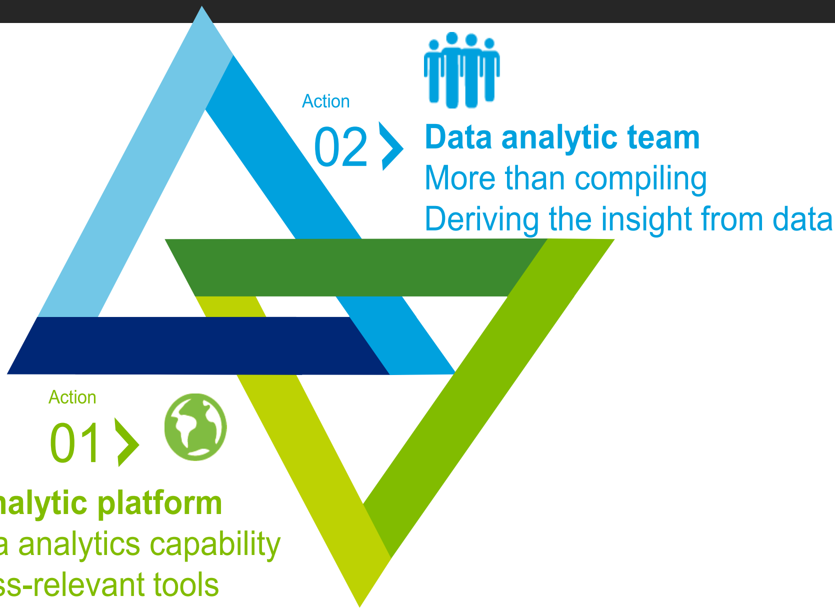


[Implemented Digital Technologies in Water Supply System]

Source : K-water

8.2 Implementing Data Analytics

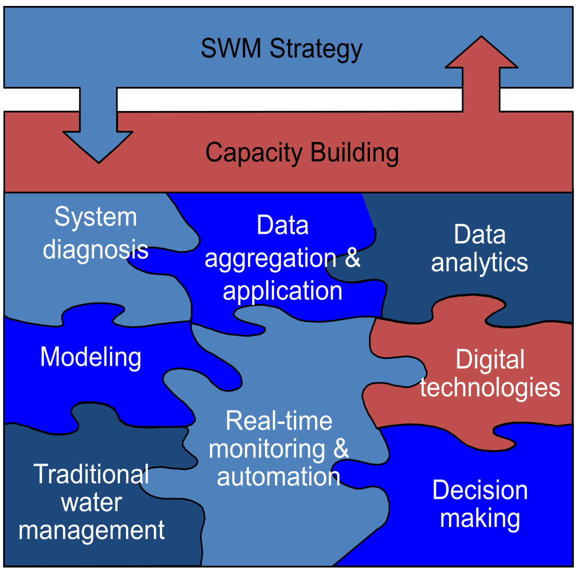
- (Data analytics) To deliver actionable insight, data analytic program such as establishing data analytic platform and building a data analytics team is planned and carried out



[Two Major Actions for Implementing Data Analytics]

8.3 Building Base Capabilities in Key Areas

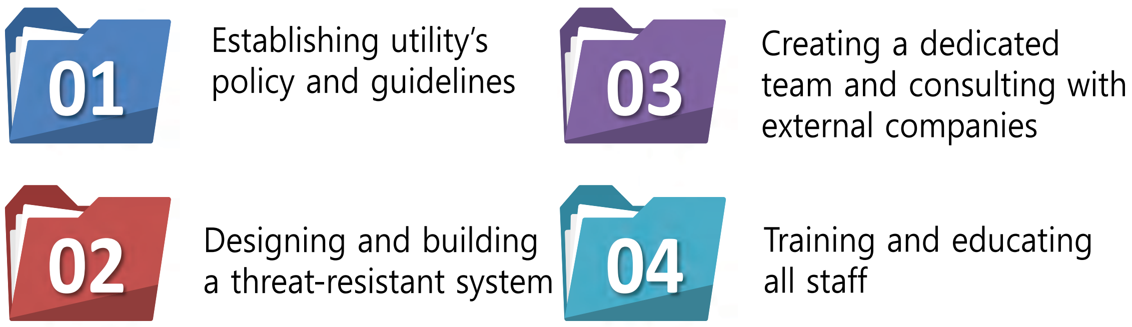
- (Key areas in capacity building) Water utilities can improve efficiency and optimize service provision through building far-reaching base capabilities in key areas



[Key Areas for Capacity Building in SWM]

8.4 Securing Cybersecurity

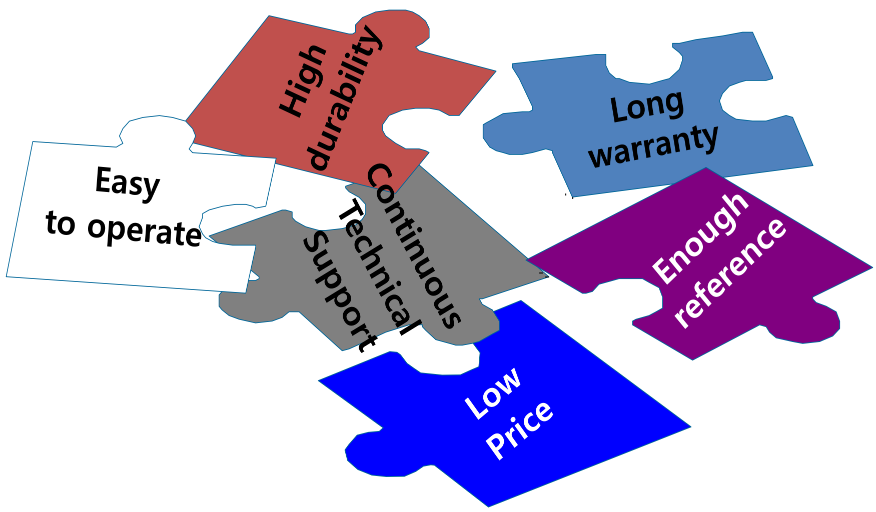
- **(Key motivators) Water utilities should understand the internal and external threats and their vulnerable system and run a wide range of practices to deal with related issues**



[Programs for Securing Cybersecurity]

8.5 Modifying Pathways for Procurement

- **(Changing procurement) Water utilities can consider a different procurement way for digital technologies because in some cases, traditional procurement way does not fit for disruptive technologies**



[Strict Mandatory Requirement for Traditional Procurement]

9. SWM Project Implementation

9.1 SWM Project Implementation

9.1 SWM Project Implementation (1)

- (Implementation) SWM project should be implemented based on the existing O&M (system, guidelines, regulations, know-how) to improve O&M efficiency

Existing O&M Process

- Systems
- Guidance materials
- Regulations
- Know-how (Rules of thumb)

Implementing SWM

- Identification
- Selection
- Design
- Construction
- Monitoring
- Evaluation

Improving Efficiency

- Effectiveness
- Efficiency
- Accountability
- Transparency
- Fairness
- Participation

9.1 SWM Project Implementation (2)

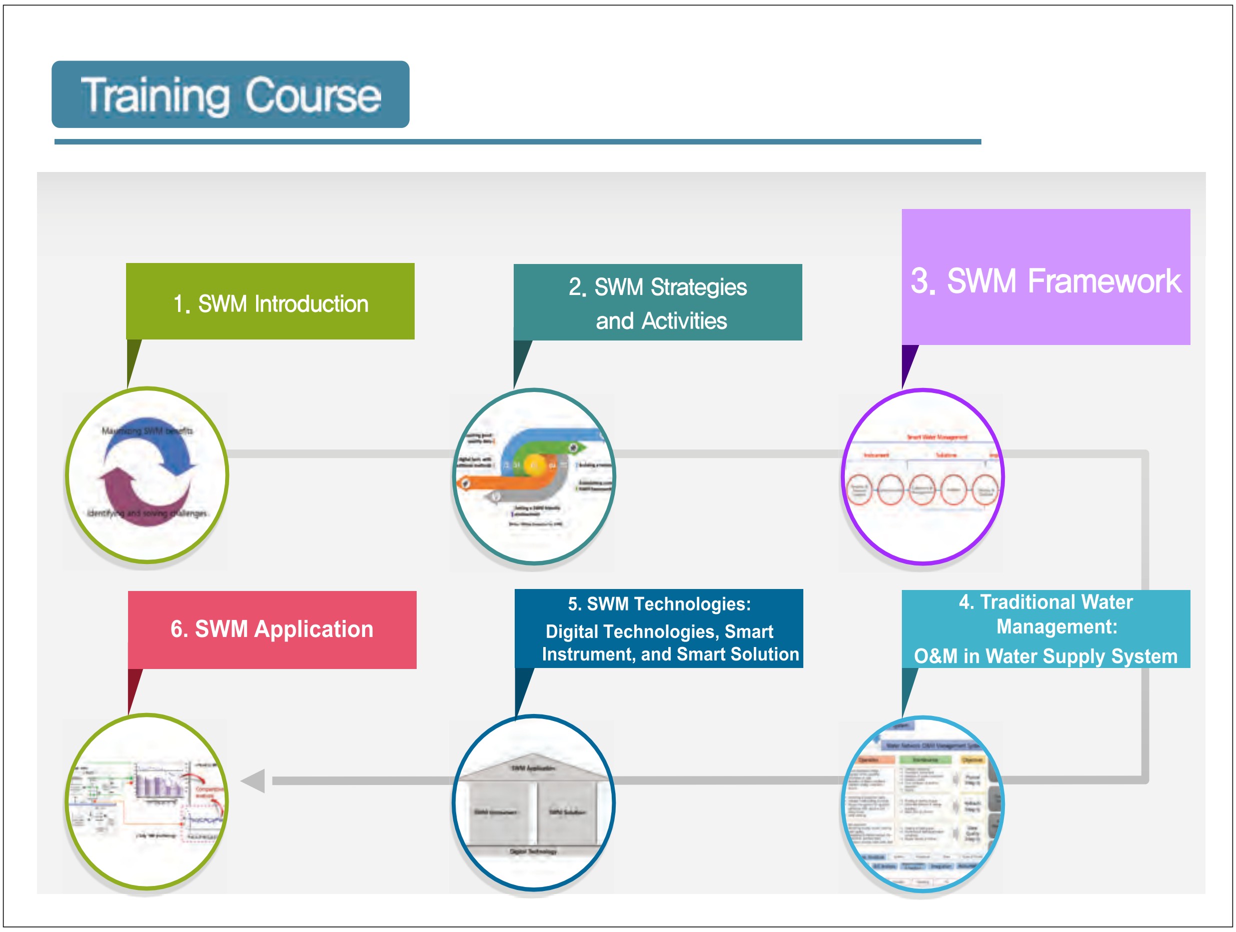
- **(Procedure) The current system analysis, establishing objectives & selecting methods, design & construction and monitoring/evaluation process is required for the implementation of SWM**

Procedure	Details
Status analysis	- Update the existing basic data - Analysis of current system problems and major issues through system diagnosis (hydraulics, water quality, facilities) using basic data * IWS, high NRW, water quality, energy efficiency * aged infrastructure, poor data management
Establishment of SWM purpose and application method	- Establishment of customized SWM application plan based on current status analysis - Holistic approach with various SWM technologies according to purpose, not single SWM technologies
Design & Construction	- Based on reliable modeling and experience, the appropriate location and quantity of SWM technology is determined to maximize efficiency and enhance operation
Monitoring & Performance Evaluation	- Establishment and evaluation of performance indicators

SWM Framework

Smart Water Management


3. SWM Framework
United Nations Educational, Scientific and Cultural Organization
i-WSSM
International Centre for Water Security and Sustainable Management


Training Course
1. SWM Introduction
2. SWM Strategies and Activities
3. SWM Framework
4. Traditional Water Management: O&M in Water Supply System
5. SWM Technologies: Digital Technologies, Smart Instrument, and Smart Solution
6. SWM Application

Aims & Objectives

- **The aims of the course are to:**

  (1) Provide the systematic architecture of SWM framework and mains functions of each layer constituting the framework ;

  (2) Enable trainees to establish and customize their appropriate SWM framework through benchmarking

- **The objectives are that trainees will understand:**

  (1) The role of SWM framework;

  (2) Direction of SWM framework;

  (3) The definition of layers of SWM framework

Contents

1. Overview

1.1 Backgrounds

- **(Necessity) Establishing clearer SWM framework is a key factor to success in SWM implementation**

- **(No general standard) Academia and early adopters have suggested their SWM framework, but no standardized SWM has been established due to the lack of consensus on the SWM framework**
  - Some suggested SWM framework are designed for particular purposes, so it is difficult to apply the proposed framework immediately

- **(A lack of demonstration and sharing information) There are not many cases of actual application of the proposed SWM framework, and water utilities who applied it are reluctant to disclose challenges and problems that arise when applying it**

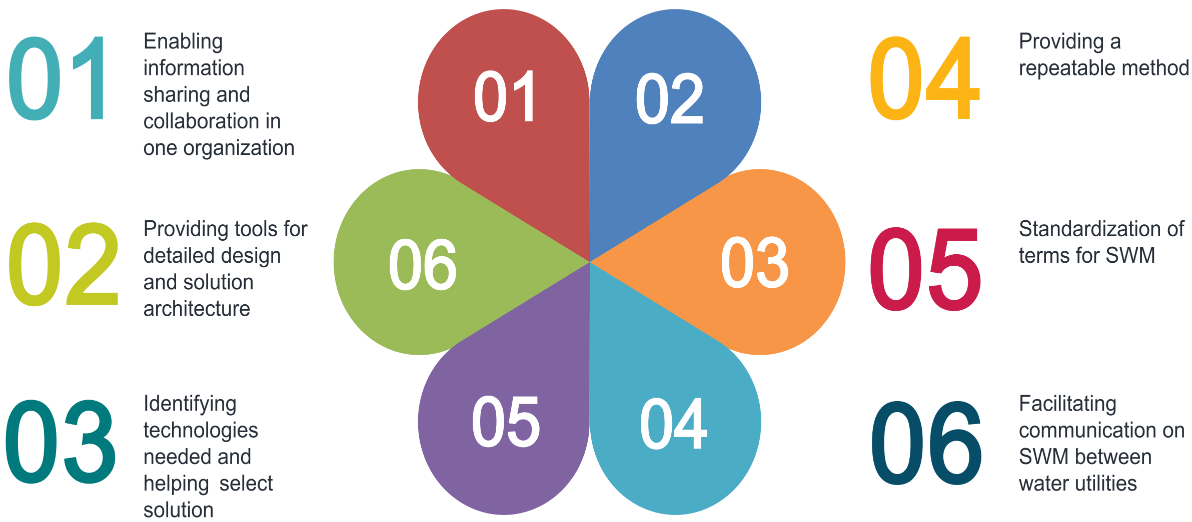
1.2 Roles of SWM Framework (1)

- (Roles of framework) Water utilities should build a systematic and customized SWM framework to guide and accelerate the implementation of SWM

[Roles of SWM Framework]

1.2 Roles of SWM Framework (2)

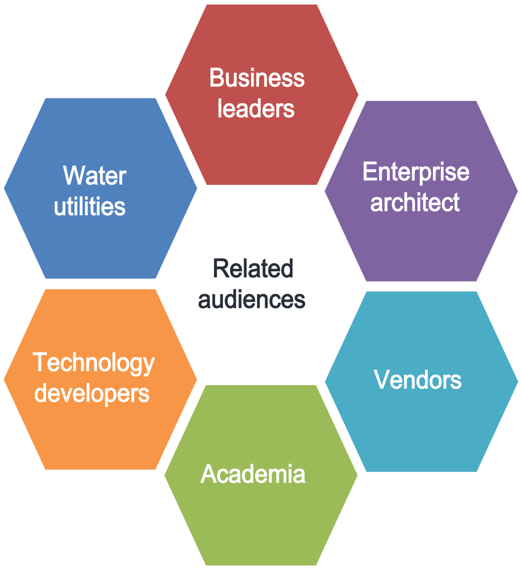
- (Specific purposes of framework) The SWM framework can be used in various ways according to the current status and necessity of the relevant water utilities



[Specific Purposes of SWM Framework]

1.3 Intended Audience

- (Audience) By establishing an appropriate and customized SWM, many related audiences can deeply understand the SWM



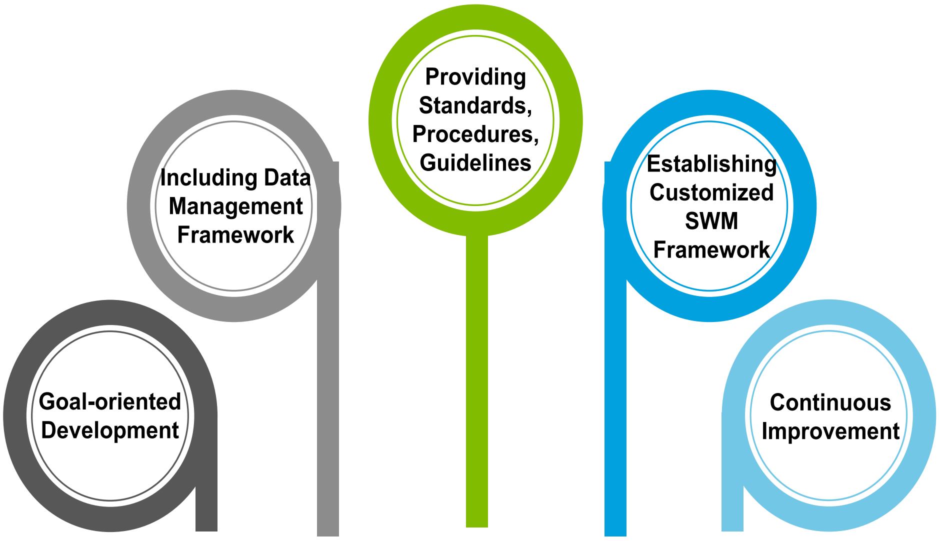
[Related Audiences on SWM Framework]

2. Direction of SWM Framework

2.1 Direction of SWM Framework
2.1 Goal-oriented Development
2.3 Including Data Management Framework
2.4 Providing Standards & Specification
2.5 Customized SWM Framework
2.6 Continuous Improvement

2.1 Direction of SWM Framework

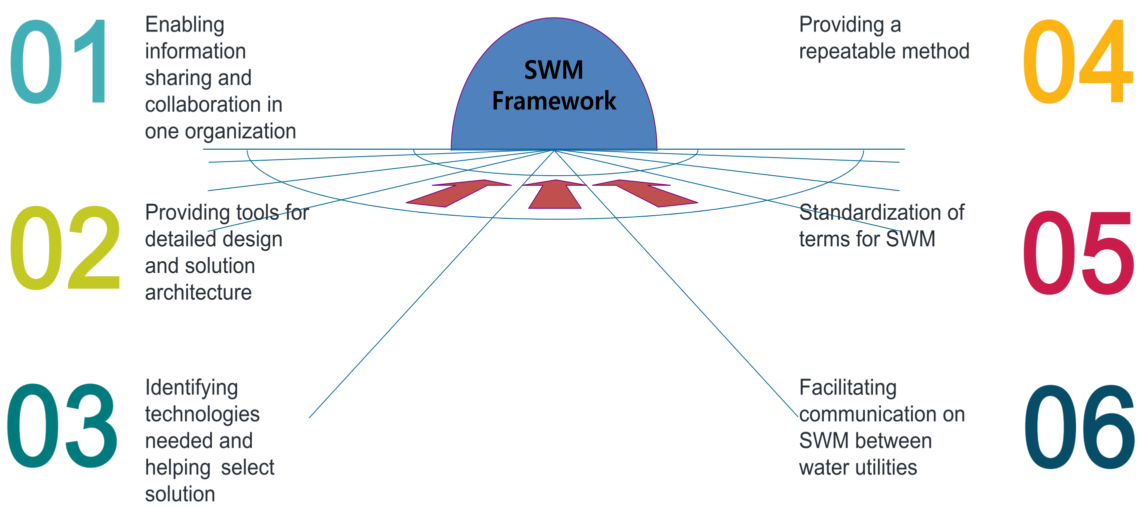
- (Direction of framework) Water utilities should develop their own SWM framework in accordance with the five direction for good practicability, expansibility, portability, and openness



[Five Direction of SWM Framework]

2.2 Goal-oriented Development

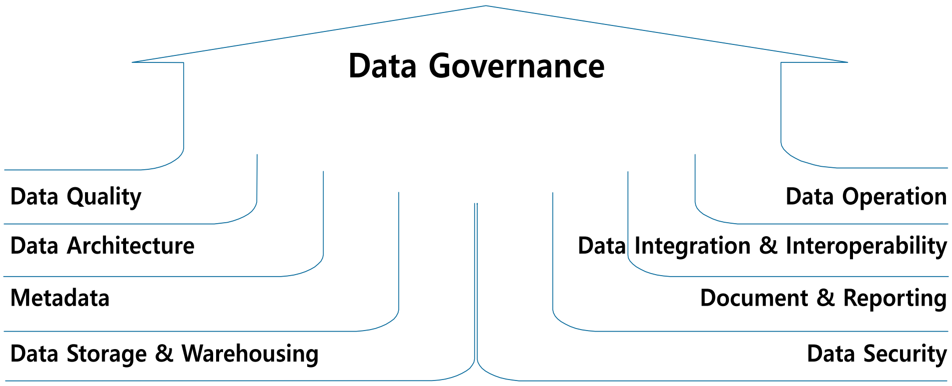
- (Goal-oriented development) Water utilities should establish the SWM framework according to the SWM purposes and application



[Goal-oriented SWM Framework Development]

2.3 Including Data Management Framework

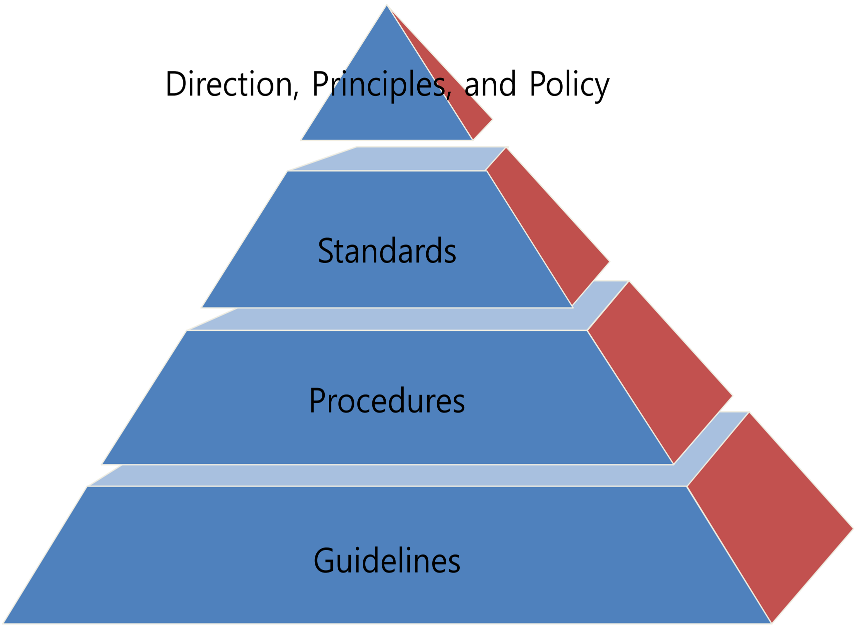
- (Data Management Framework) Data management framework which contains essential functions should be elucidated in SWM framework to have a more practical and agile data governance



[Necessities for Efficient Data Governance]

2.4 Providing Standards, Procedures, and Guidelines

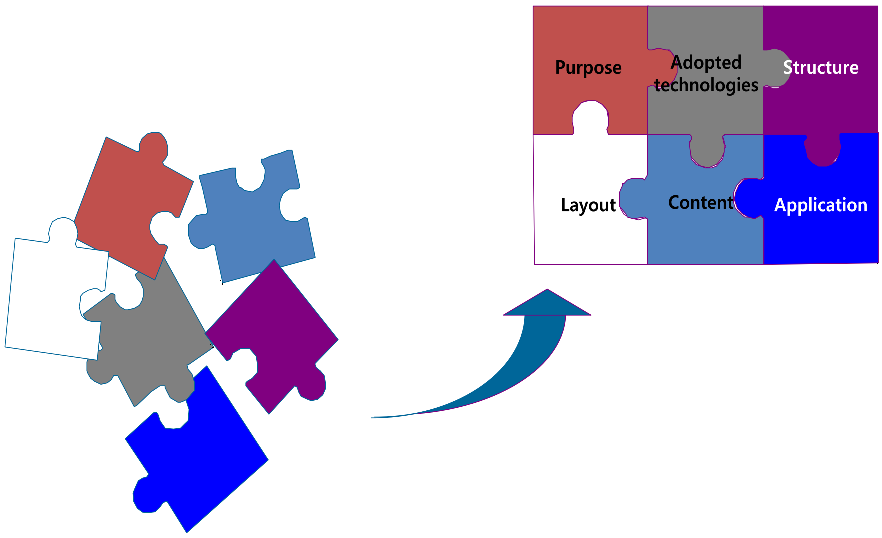
- (Good reference) SWM Framework should present detailed standards, procedures, and guidelines, not just concepts and direction



[The Structure of Direction, Standards, Procedures, and Guidelines]

2.5 Establishing Customized SWM Framework

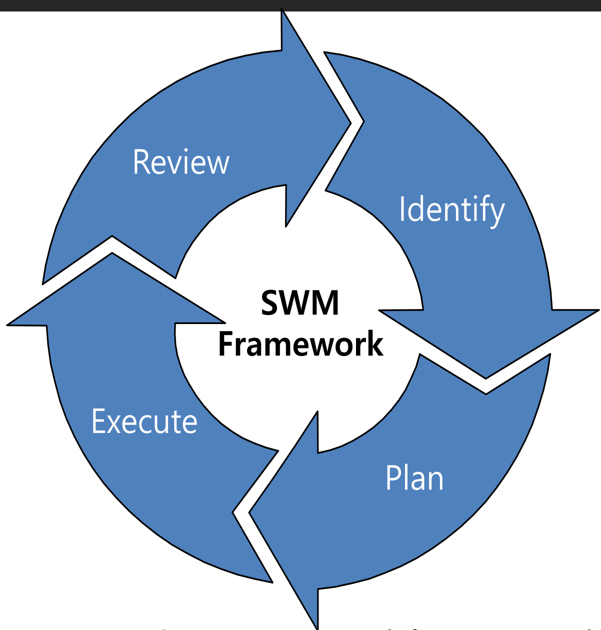
- (Customized framework) Water utilities' their own SWM framework should be established by benchmarking researchers' or early adopters' SWM framework



[The Customized SWM Framework]

2.6 Continuous Improvement

- (Continuous improving) SWM framework should be continuously improved by gradually deepening its application and optimizing data resource use



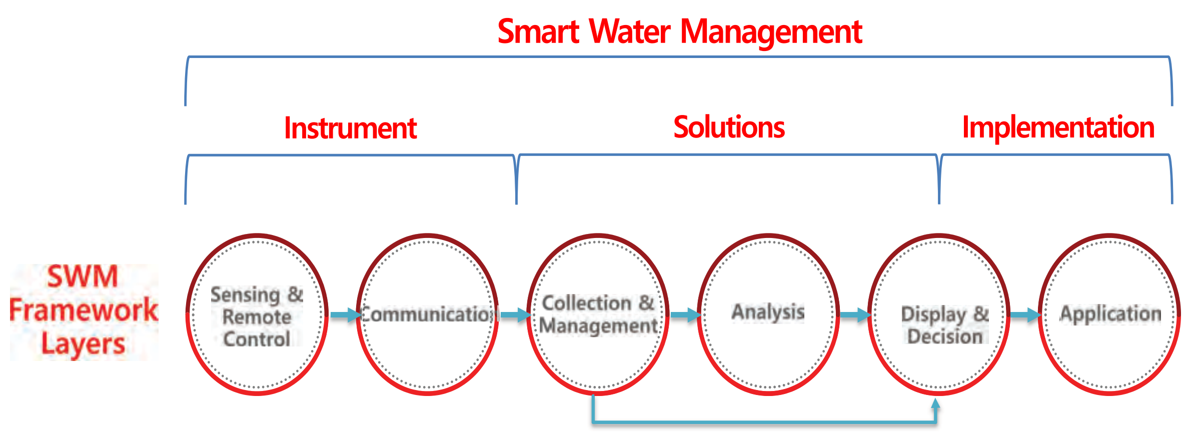
[Continuous Improvement Cycle for SWM Framework]

3. Systematic Architecture

3.1 Systematic Architecture of SWM Framework

3.1 Systematic Architecture of SWM Framework

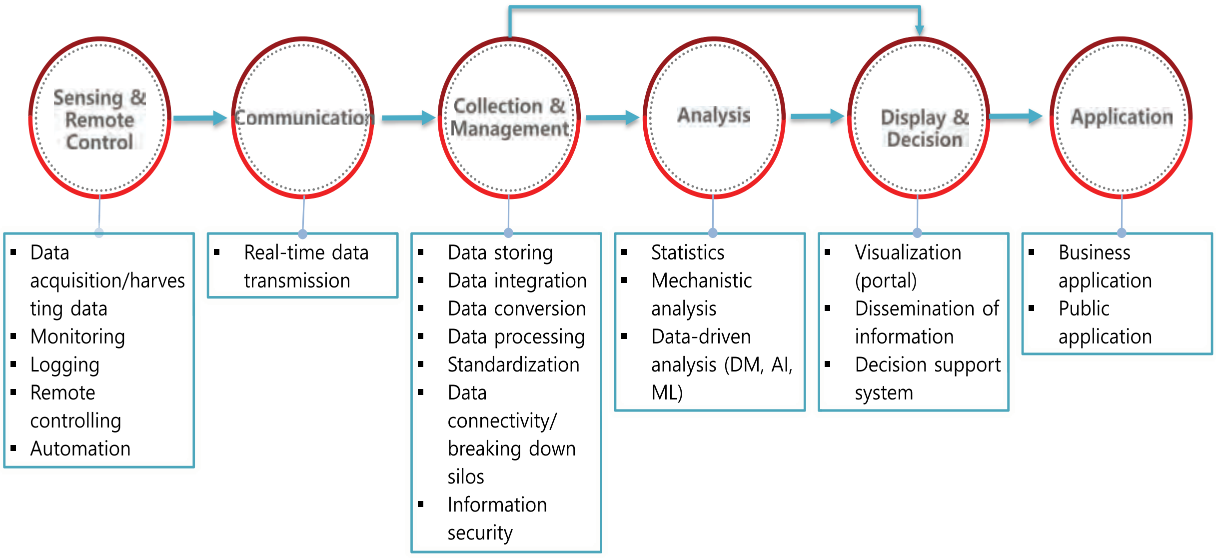
- (SWM framework) SWM Framework, a backbone of SWM, has a systematic architecture composed of various layers working synergistically to perform useful functions and applications



[Smart Water Management Framework]

3.1 Systematic Architecture of SWM Framework

- (Layers) The overall framework of SWM system is composed of six layers, such as sensing & remote control, communication, collection and management, analysis, display, and application layer



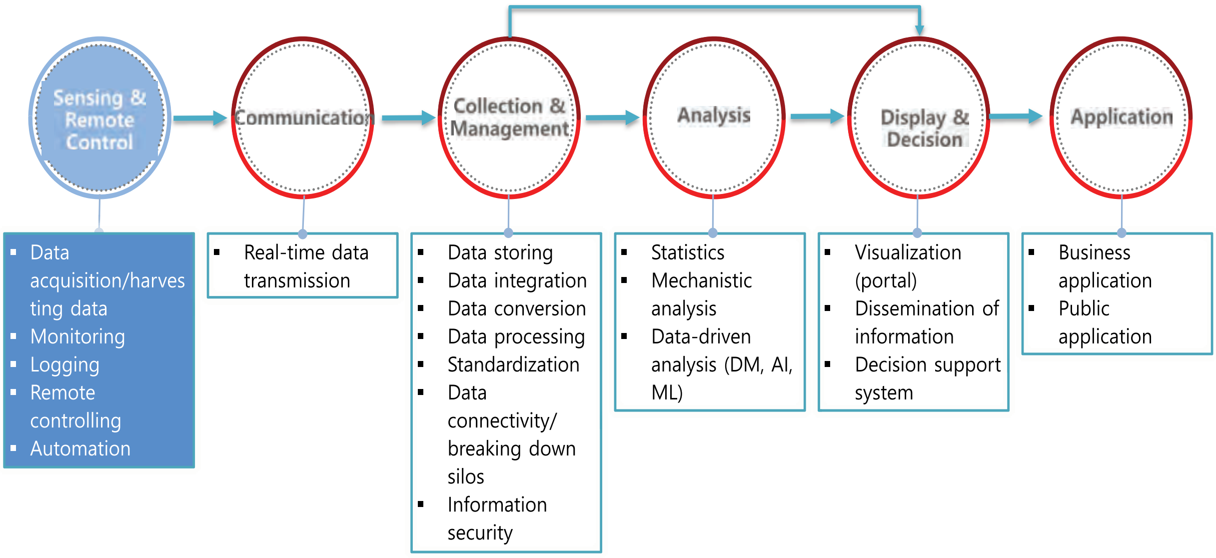
[Systematic Architecture of SWM Framework]

4. Sensing & Remote Control Layer

4.1 Sensing & Remote Control Layer
4.2 Functions of Sensing & Remote Control Layer

4.1 Sensing & Remote Control Layer

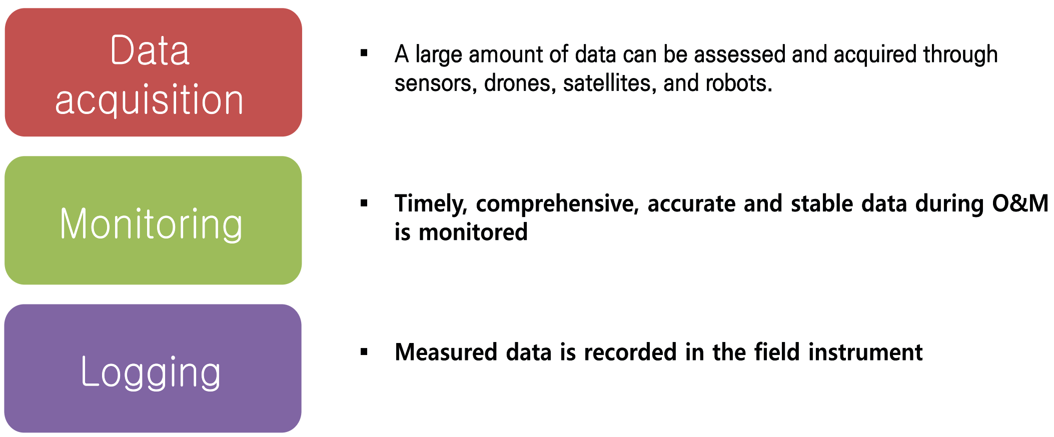
- (Definition) The sensing & remote control layer should be designed to realize the timely, comprehensive, accurate and stable monitoring and controlling through sensing, IoT, SCADA, PLC, and etc. on the physical asset



[Sensing & Remote Control Layer]

4.2 Functions of Sensing & Remote Control Layer (1)

- (Functions) Data acquisition (harvesting data), monitoring, logging, automation, and remote controlling are the main function in the sensing & remote control layer



[Functions of Sensing & Remote Control Layer #1]

4.2 Functions of Sensing & Remote Control Layer (2)

Automation	▪ By using measured data, initial parameter setting, simple analysis and forecast, actions is set and instructed
Remote-controlling	▪ By using real-time data, control center can provide feedback and instruction

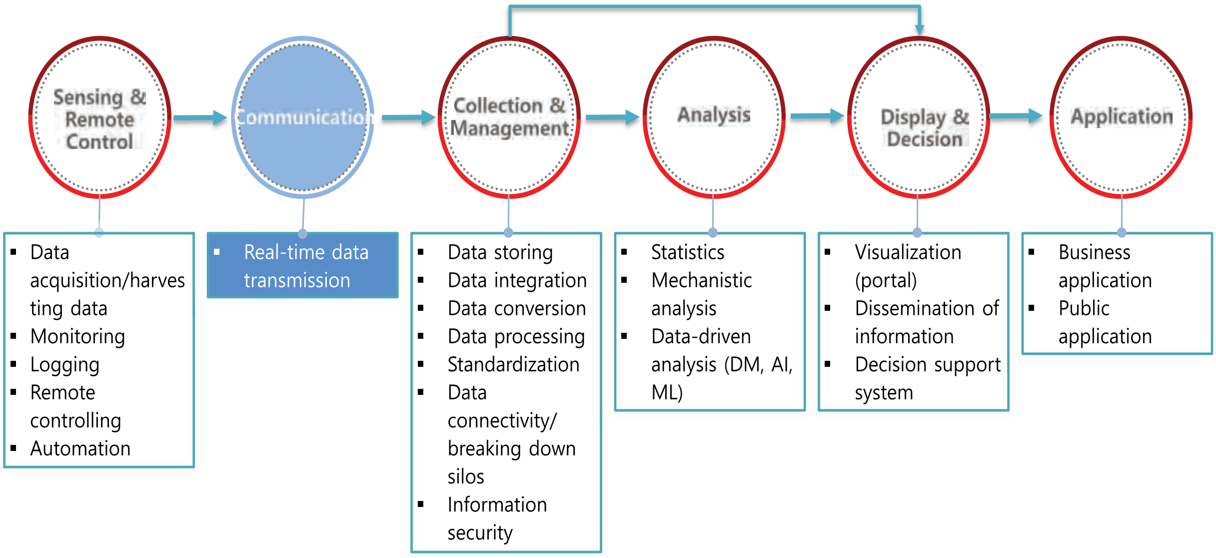
[Functions of Sensing & Remote Control Layer #2]

5. Data Communication Layer

5.1 Data Communication Layer
5.2 Functions of Data Communication

5.1 Data Communication Layer

- **(Definition) The data communication layer should be designed to provide information transmission channel and safe operation environment and transmit the data quickly, safely, and stably through wired or wireless infrastructure**



[Data Communication Layer]

5.2 Function of Data Communication Layer

- **(Functions) The transmission of real-time data obtained by the sensing and remote controlling layer are the main function in the data communication layer**

Real−time Transmission

- The massive heterogeneous water data are transmitted from sensor to the data center
- Real−time is the vital property of SWM
- A secure and robust wireless communication network should be established

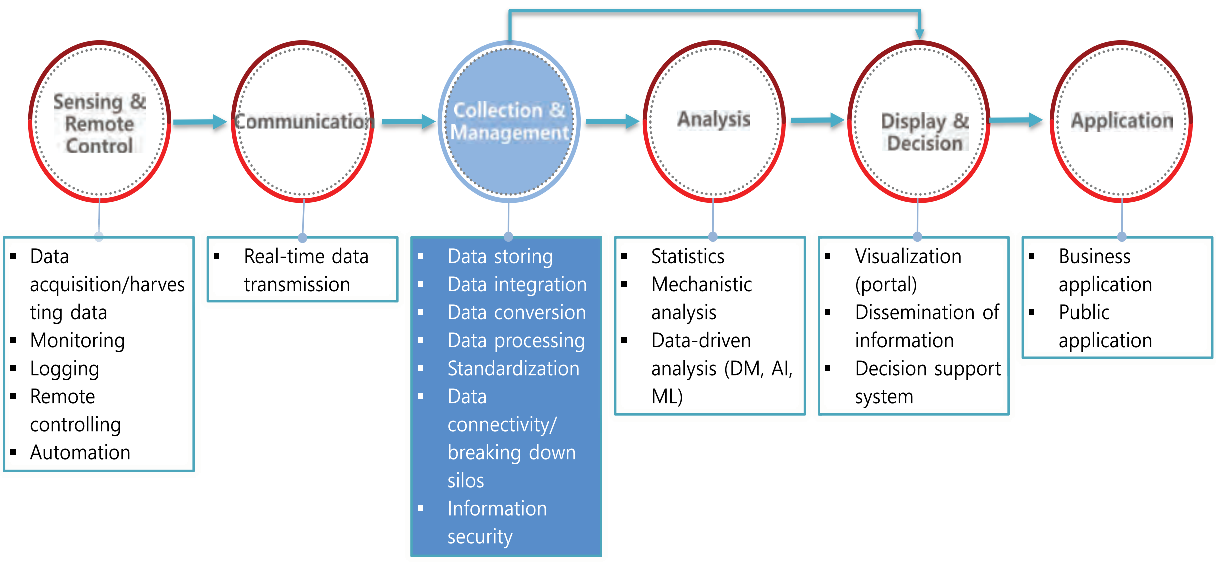
[Functions of Data Communication Layer]

6. Data Collection & Management Layer

6.1 Data Collection & Management Layer
6.2 Functions of Data Collection & Management Layer

6.1 Data Collection & Management Layer

- (Definition) The data collection & management layer should be designed to store and manage the large volume of data transmitted from the communication layer



[Data Collection & Management Layer]

6.2 Function of Data Collection & Management Layer (1)

- (Functions) Managing the data (e.g., storing, integration, conversion, processing, and standardization) and establishing data management infrastructure (e.g., connectivity and security) are the main function in the data collection & management layer

Storing

- How to storing and archiving data is important to access and use data easily and keep security

Integration

- In addition to the measured data transmitted from transmission layer, other data (e.g., geographical, asset, pipe burst, customer, billing data) should be integrated

Conversion

- The process of translating data from one format to another is needed

[Functions of Data Collection & Management Control Layer #1]

6.2 Function of Data Collection & Management Layer (2)

Processing

- Missing value and outlier should be treated for further analysis
- Featuring engineering methods (e.g., scaling, binning, transform, dummy) can be used to extract more data

Standardization

- Data should be Standardized to ensure the interconnection of all stored data and corporation between different divisions and organizations

Connectivity

- Collected data should be shared
- Breaking data silo is crucial and consolidated data can be used to derive practical use

Information Security

- To ensure the safety and stability of the data collection and management system, information security should be guaranteed

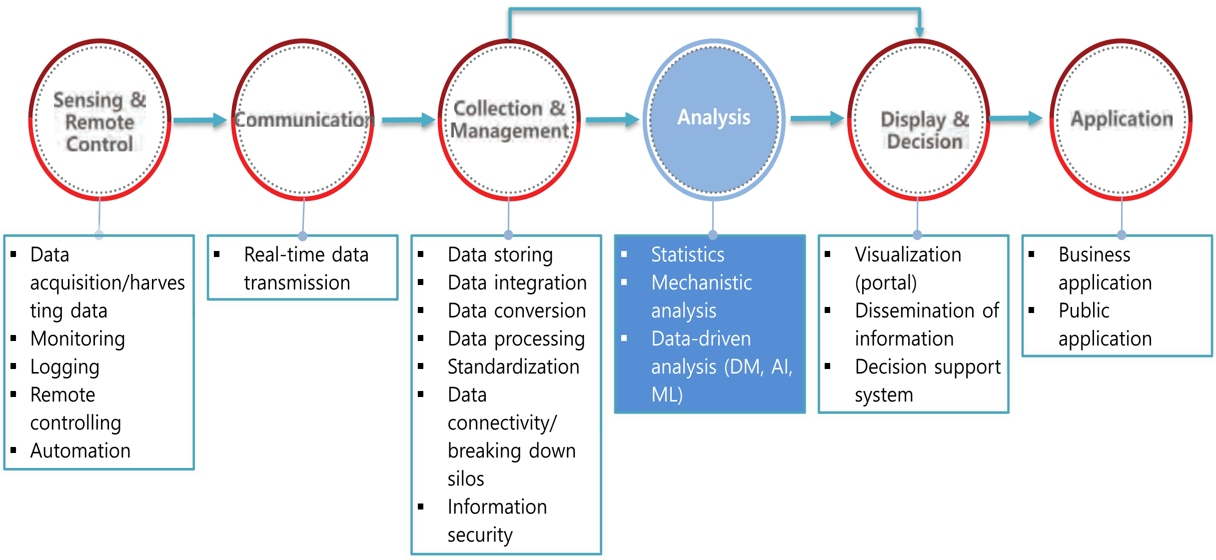
[Functions of Data Collection & Management Control Layer #2]

7. Data Analysis Layer

7.1 Data Analysis Layer
7.2 Functions of Data Analysis Layer

7.1 Data Analysis Layer

- (Definition) The data analysis layer should be designed to analyze collected and managed data and generate actionable insights for holistic O&M decision making



[Data Analysis Layer]

7.2 Function of Data Analysis Layer

- (Functions) Data analysis through statistics, mechanistic analysis (mathematical model analysis), and data-driven analysis (e.g., data mining, artificial intelligence, machine learning) are the main function in the data analysis layer

Statistics
- Descriptive, Exploratory, and Inferential Analysis
- Taking data from the past and present to find relationships

Mechanistic analysis
- Causal and predictive analysis
- Taking data from the past and present to identify causality and provide improvement

Data-driven analysis
- Predictive analysis
- Taking data from the past and present to make predictions about the future

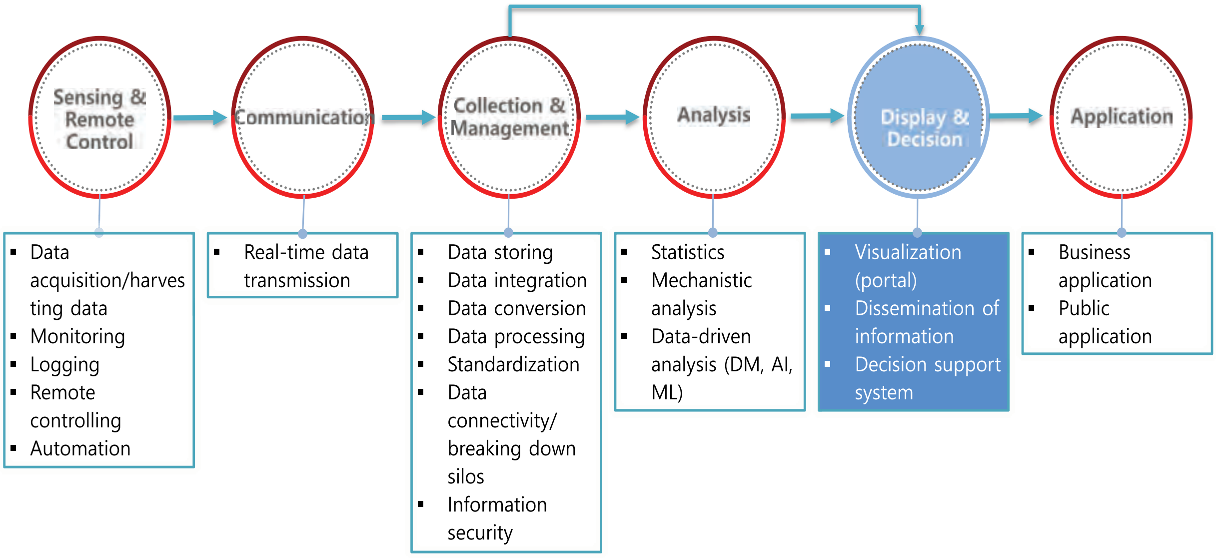
[Functions of Data Analysis Layer]

8. Display & Decision Layer

8.1 Display & Decision Layer
8.2 Functions of Display & Decision Layer

8.1 Displayer & Decision Layer

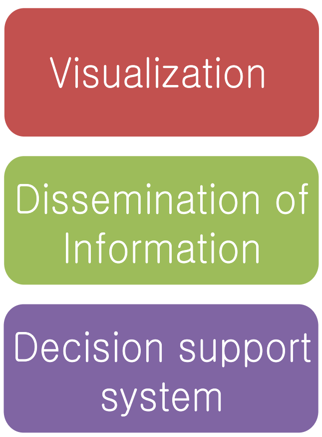
- **(Definition) The display & decision layer should be designed to provide current O&M status (e.g., monitored data, analysis results), share the information, and facilitate the decision-making through portal**



[Display Layer]

8.2 Function of Display & Decision Layer

- **(Functions) Visualization, dissemination of information, and decision support system are the main function in the display & decision layer**



- Monitored data and analyzed results are visualized through portal
- Portal including PC and mobile portal is the unified entrance of the whole SWM

- **Data should be shared with employees of all departments**
- **Through this, employees can use data to come up with new ideas to improve O&M**

- **Optimization decisions and management steps are taken from the monitored data and analyzed results**

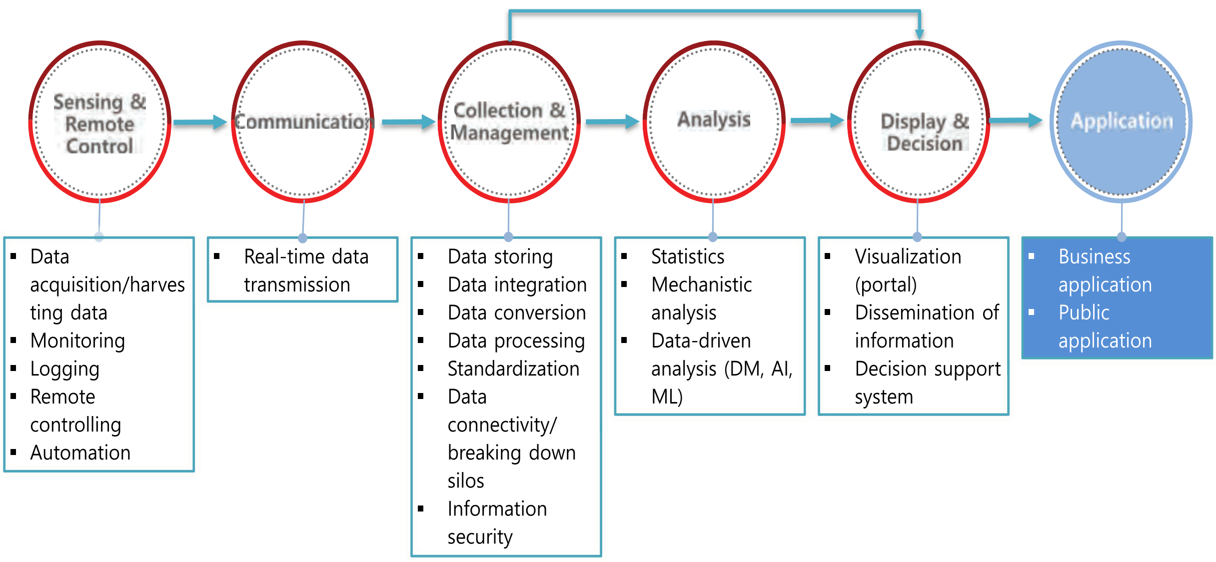
[Functions of Display Layer]

9. Application Layer

9.1 Application Layer
9.2 Functions of Application Layer

9.1 Application Layer

- **(Definition) The application layer should be designed to integrate the digital technologies & solutions with traditional O&M tasks**



[Application Layer]

9.2 Function of Application Layer

- (Functions) Business application and public application are the main function in the application layer

Business Application

- Reducing water loss & energy loss
- Optimizing pressure & water quality
- Prolonging asset life cycle and cost saving

Public Application

- **Sharing real-time data and information with consumers**
- **Receiving feedback on billing and consumption**

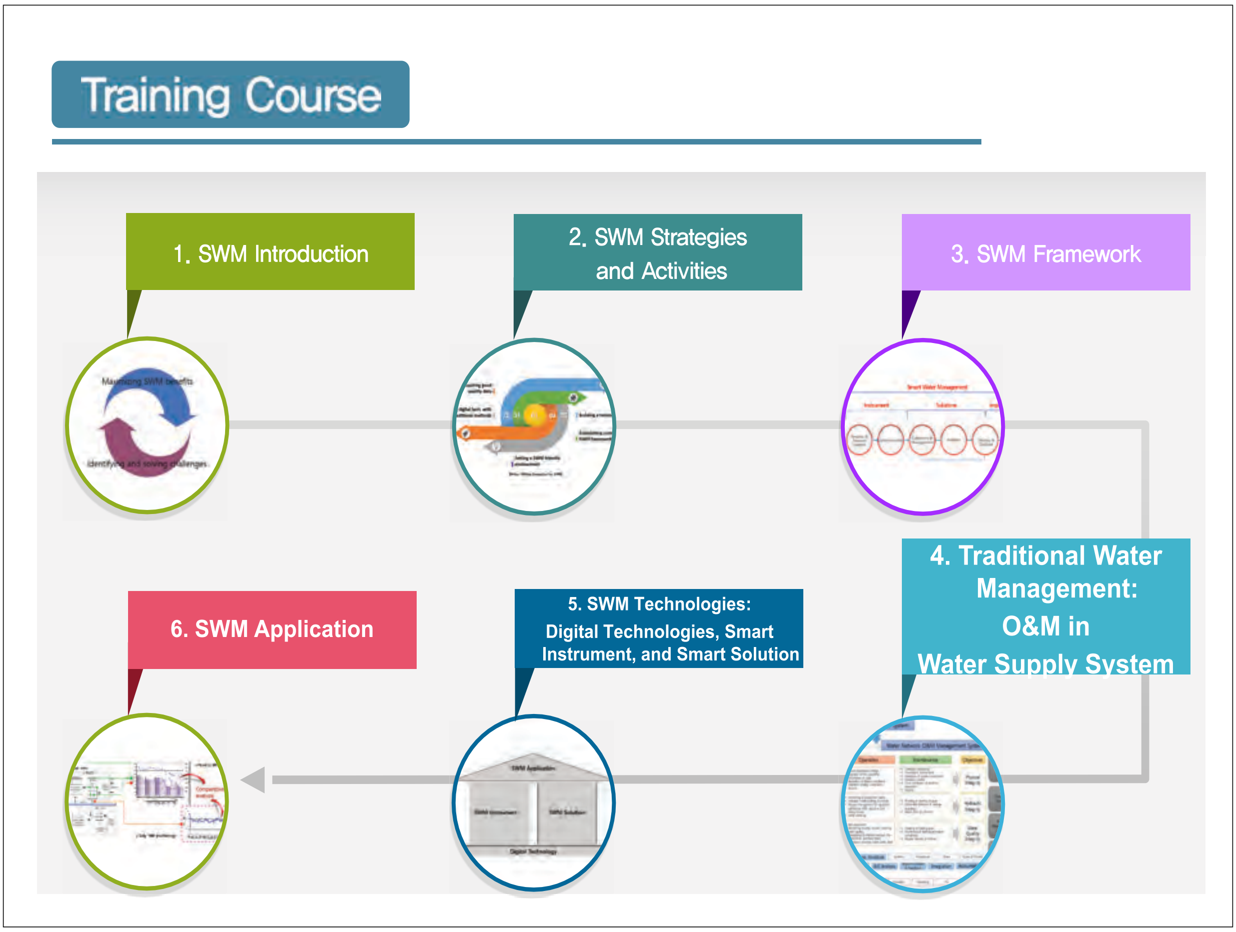
[Functions of Application Layer]

Thank you very much

Traditional Water Management: O&M in Water Supply System

Smart Water Management


4. Traditional Water Management:
O&M in Water Supply System
United Nations Educational, Scientific and Cultural Organization
i-WSSM
International Centre for Water Security and Sustainable Management


Training Course
1. SWM Introduction
2. SWM Strategies and Activities
3. SWM Framework
4. Traditional Water Management: O&M in Water Supply System
5. SWM Technologies: Digital Technologies, Smart Instrument, and Smart Solution
6. SWM Application

Aims & Objectives

- **The aims of the course are to:**

  (1) Provide knowledge of traditional water management, especially in O&M of water supply system;

  (2) Enable trainees to identify areas to which SWM is to be applied through the understanding of basic O&M

- **The objectives are that trainees will understand:**

  (1) The objectives of traditional O&M

  (2) Activities in O&M

  (3) Challenges and issues in O&M

Contents

1. Overview

1.1 Backgrounds
1.2 Low Priority on O&M
1.3 Importance of O&M

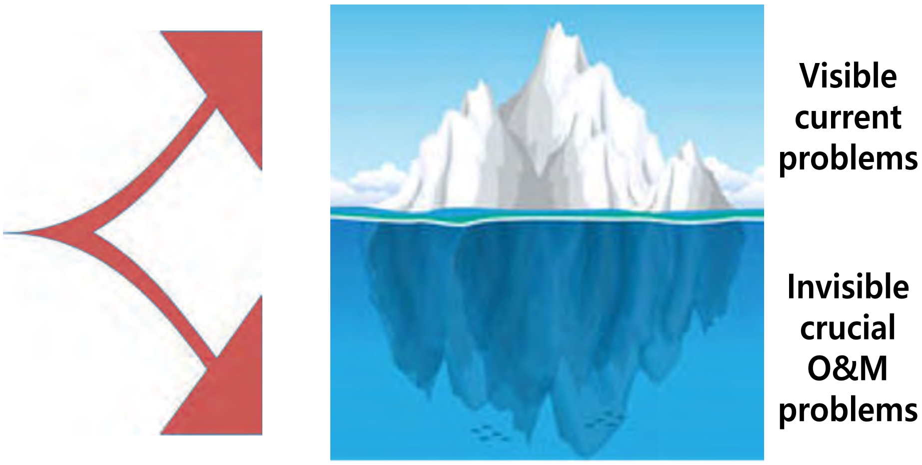
1.1 Backgrounds

- (O&M) The term, O&M, has been used as a general concept covering a wide range of activities to sustain their services and to maintain existing capital assets

	Operation	Maintenance
Definition	- It refers to the procedures and activities involved in the actual delivery of services	- It refers to activities aimed at keeping existing capital assets in serviceable conditions
Objectives	- Monitoring the system status - Running the system - Enforcing policies and procedures	- Condition assessment - Repair and replacement of system components

1.2 Low Priority on O&M

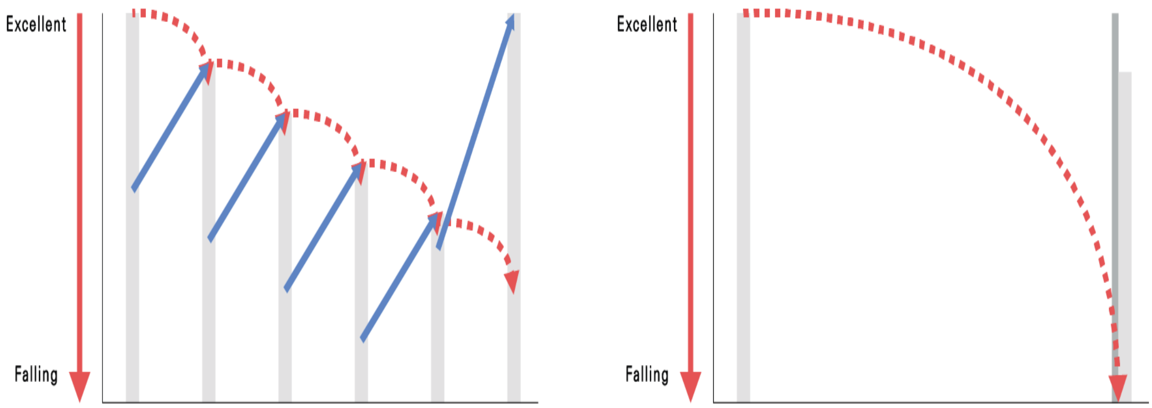
- (Low priority) The water utilities tend to focus on the current visible problems rather than invisible crucial O&M problems that have long-term impacts



[Low Priority on Invisible Crucial O&M Problems]

1.3 Importance of O&M

- (Sustainability) Without proper O&M, Asset will soon decline to a point where service provision is compromised and it will lead to greater water losses, financial losses and health risk to consumers
- (Importance) Money saved on maintenance of assets is never a saving



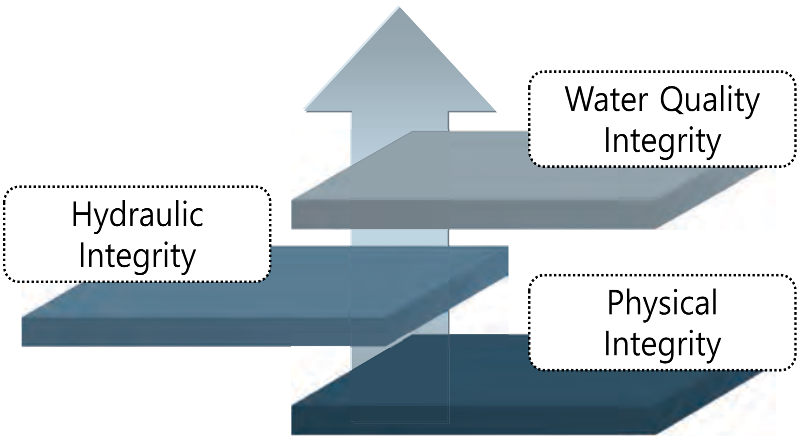
[Asset Status with or without Maintenance]

2. Traditional O&M

2.1 Objectives of O&M
2.2 Activities in O&M
2.3 Process for Establishing O&M Management System

2.1 Objectives of O&M

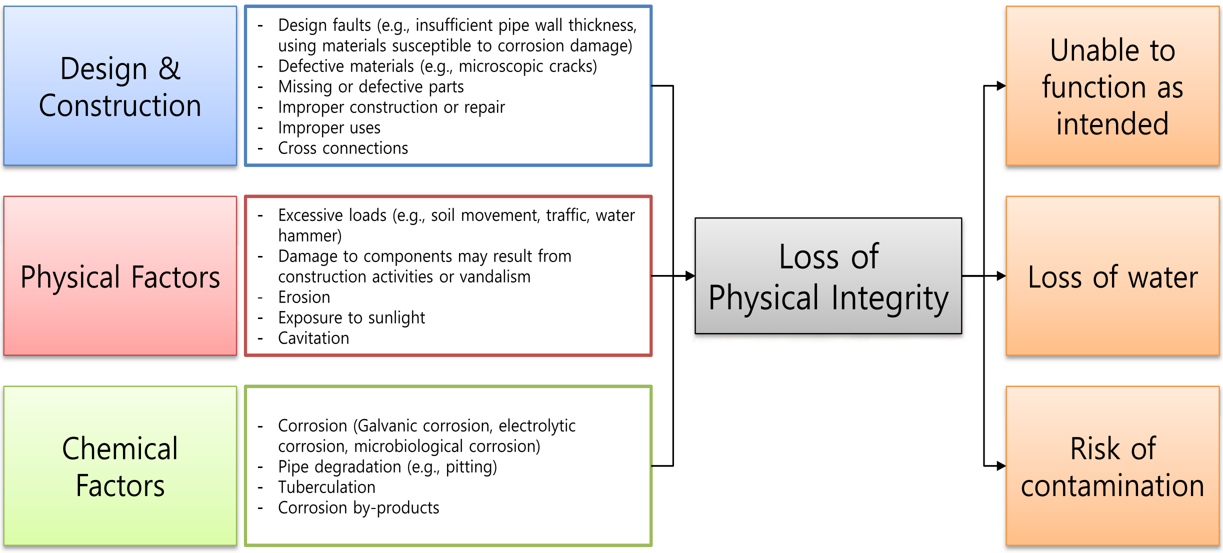
- (Objectives) The main objectives of O&M is to maintain physical, hydraulic, and water quality integrity



[Main Objectives of O&M]

2.1 Objectives of O&M

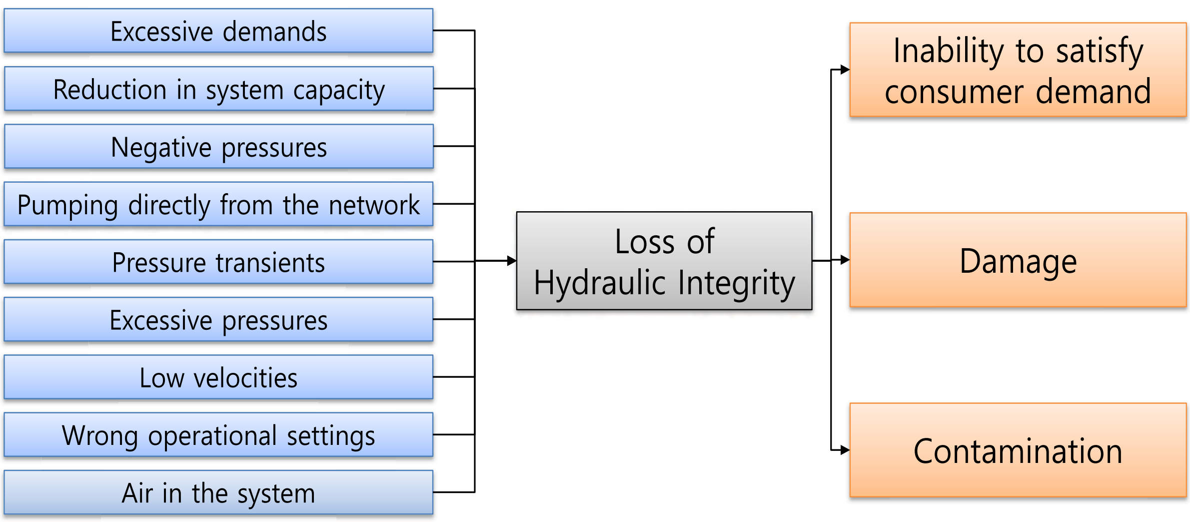
- **(Physical integrity) Physical integrity means ability to have correctly functioning components and maintain a physical barrier**



[Causal-consequential path of loss of physical integrity]

2.1 Objectives of O&M

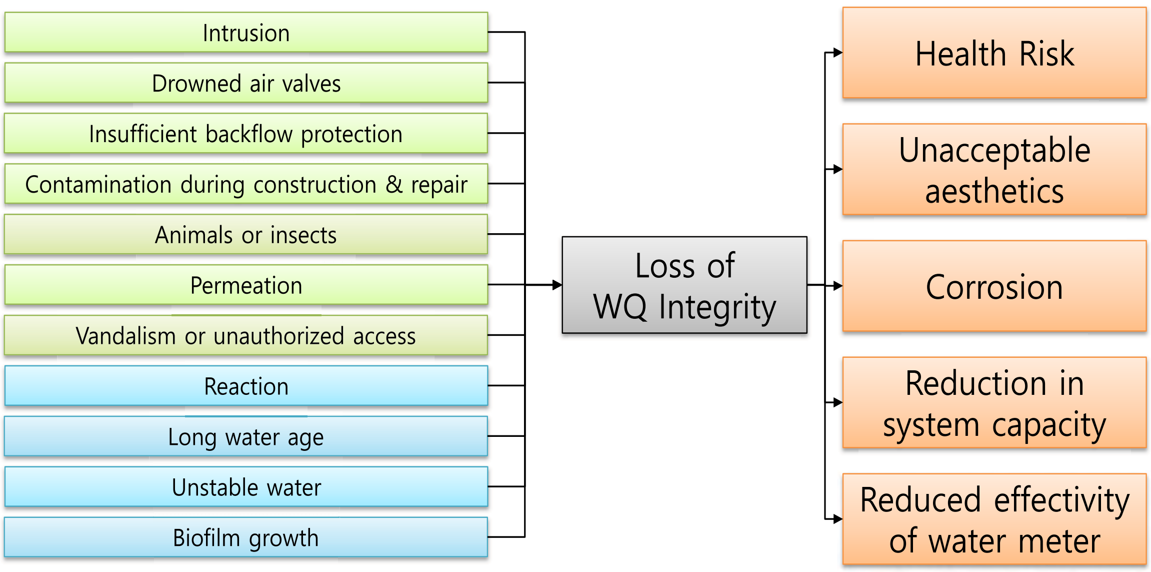
- **(Hydraulic integrity) Hydraulic integrity means ability of a distribution system to meet all user demands while ensuring desirable pressures, velocities and water age in the system**



[Causal-consequential path of loss of hydraulic integrity]

2.1 Objectives of O&M

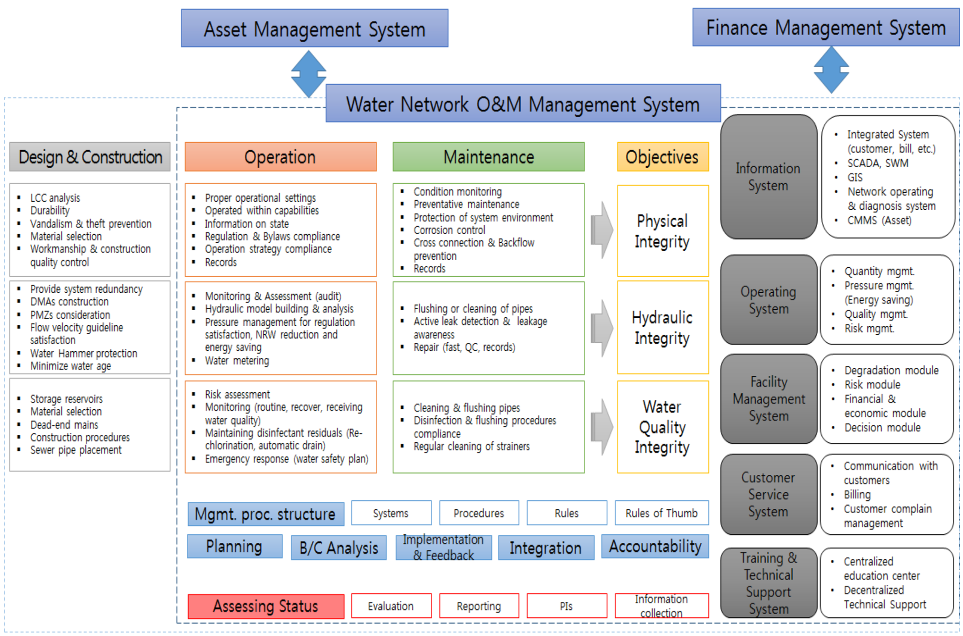
- **(WQ integrity) Water quality integrity means ability of a distribution system to deliver water of acceptable quality to its users**



[Causal-consequential path of loss of water quality integrity]

2.2 Activities in O&M

- **(Activities) Several activities are performed to achieve the objectives, and water utilities establish systems, procedures, and rules to facilitate activities**



[Activities and Systems in Design & Construction, Operation, and Maintenance Process]

2.3 Process for Establishing O&M Management System

- (Establishing O&M System) It is important for water utilities not to have a system that can handle all O&M activities, but to have a system for solving key problems faced

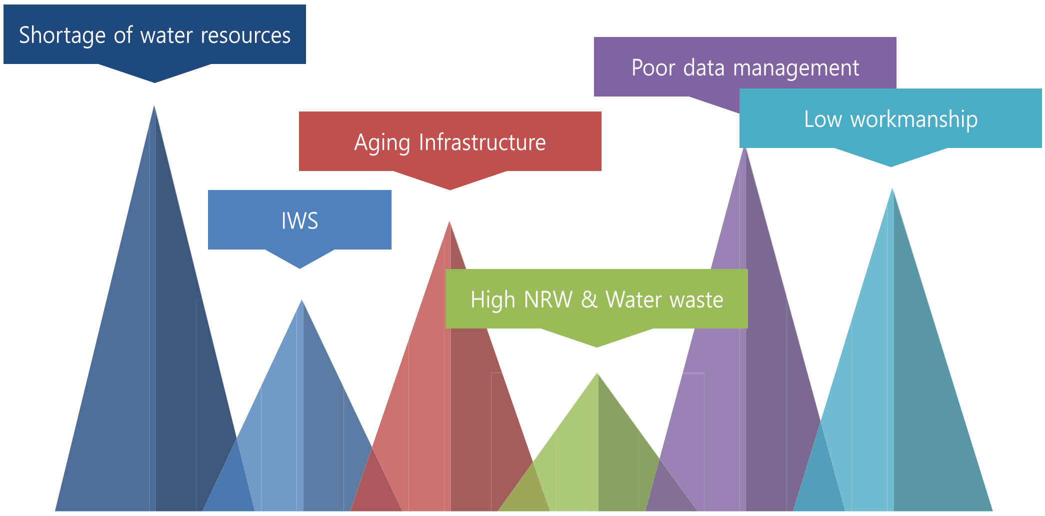
No.	Main tasks	Details (examples)
1	Identify key issues (Identify problems causes and consequences)	- Technical issues - Humana resources management - Data systems - Funding - Public participation - Accountability
2	Establishment objects of O&M	- Equal supply - Reduce intermittent supply - NRW reduction - Energy saving - Increase tap water drinking percentage
3	Design O&M systems (Select required & established Systems)	- Information system - Operating system - Facility management system - Customer service system - Training & Technical support system
4	Equip with by-laws, detail procedures, guidelines, handbooks, etc.	- Data quality control - Leak detection methods - Water audit (top-down, bottom-up) - DMA and PMZ establishment - Active pressure management
5	Design O&M team structure	- Customer service, operation, facility management
6	O&M BC analysis	- Expected revenue calculation - Detail cost calculation

3. Challenges and Issues in O&M

3.1 Challenges and Issues
3.2 Shortage of Water Resources
3.3 Intermittent Water Supply
3.4 Aging Infrastructure
3.5 High Non-revenue Water
3.6 Poor Data Collection, Storage, and Organization
3.7 Water Waste
3.8 Low Workmanship

3.1 Challenges and Issues

- **(Problems) Shortage of water resources, intermittent water supply, aging infrastructure, high non-revenue water, poor data management, water waste, and low workmanship are the crucial problems in O&M**



[General Problems in O&M]

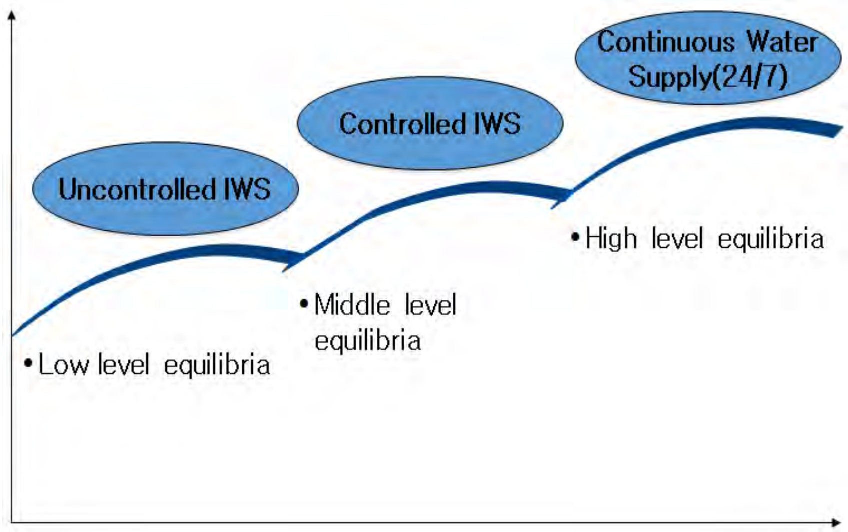
3.2 Shortage of Water Resources

- **(Shortage of water) Shortage of water resources may cause several problems and there are only expensive solutions (e.g., developing new water resources, importing bulk water from other region)**

[Problems Caused by Water Resource Shortage]

3.3 Intermittent Water Supply

- (IWS) Intermittent water supply (IWS) is piped water supply that is delivered less than 24 hours a day and IWS has been implemented in attempt to distribute available water to as many people as possible



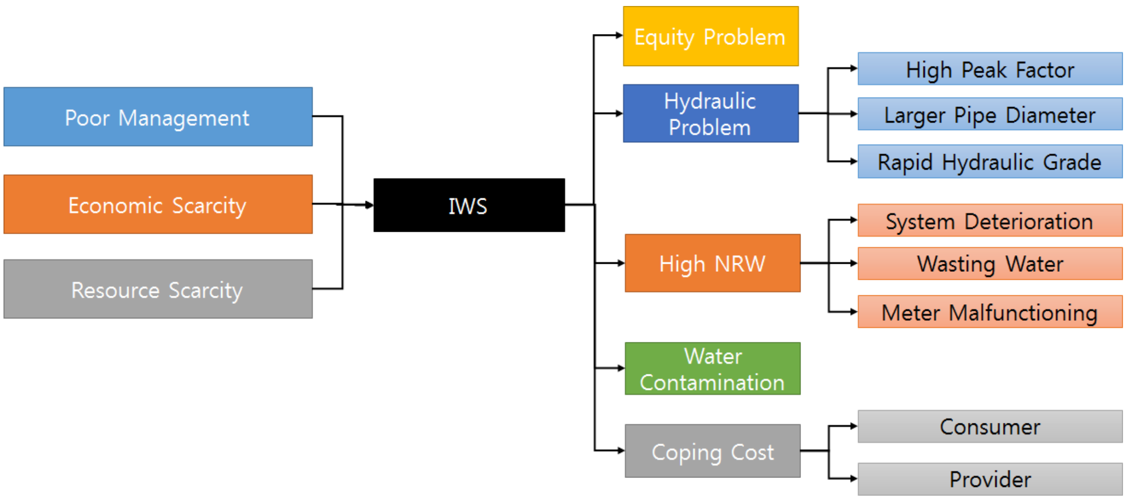
[Water Supply Types]

3.3 Intermittent Water Supply

	Definition	Operation Objectives
Uncontrolled Intermittent Water Supply	- Low level equilibria - IWS is mainly caused by poor O&M and economic problems	- Delivering water to as many people as possible
Controlled Intermittent Water Supply	- Middle level equilibria - IWS is mainly caused by water resource scarcity - Water utility improves its network to such an extent that water loss is very small, it was faced with a situation beyond its control	- The limited quantity of water should be distributed as fairly and equally as possible to achieve better supply for people
Continuous Water Supply(24/7)	- High level equilibria	- Supplying sufficient quantities of water to the consumers at adequate pressures and at affordable cost

3.3 Intermittent Water Supply

- (Causality) In many cases, the main reason of IWS is not only water resource scarcity but also poor O&M management



[The Cause-and-effect Relationship in Intermittent Water Supply]

3.3 Intermittent Water Supply

- (Strategies) Strategies for handling IWS can be classified into 2 categories (i.e., direct transfer from intermittent supply to 24-hour supply and minimizing negative impacts of intermittency over consumers) and the two strategies are no necessarily conflicting each other

[Two Strategies for IWS Management]

3.3 Intermittent Water Supply

- (Activities) To manage IWS, a holistic approach with several activities such as establishing criteria, NRW reduction, increasing tariffs, creating conditions, and developing alternative resources should be implemented

[A Holistic Approach to Manage IWS]

3.4 Aging Infrastructure

- (Aging infrastructure) With limited budget, the problems of aged water distribution infrastructure is serious and with Improper O&M, a new infrastructure is demolished in a short period

[Aging Infrastructure]

3.4 Aging Infrastructure

- **(Asset management) Asset management practices should follow a systematic, systemic, and holistic approach**

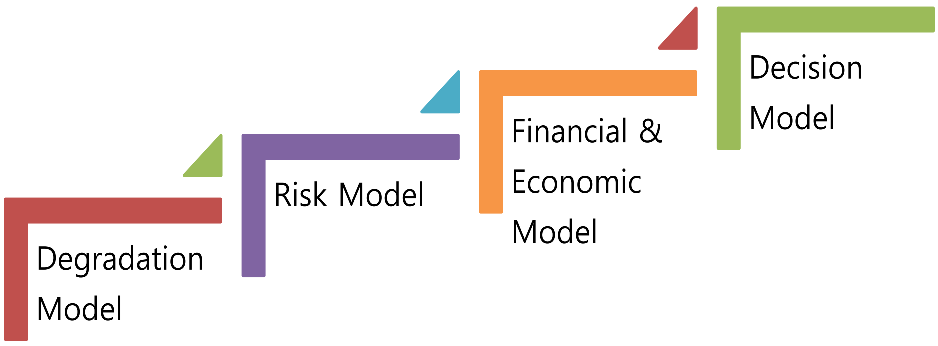
1st Generation AM Asset Information	2nd Generation AM Asset Strategies	3rd Generation AM Total Integration
What do we have? Where is it? What condition is it in? How does it perform? Maintenance Management	Optimization Risk-based System controls Failure mode analysis RCM	Coordinated strategy Service standards IT integration Financial analysis Organizational alignment
• Collecting asset data • Entering data into Computerized Maintenance Management Systems (CMMS)	• Focus on the risk of asset failure for infrastructure investment decisions • Optimize maintenance by eliminating non-value activities	• Asset management is not just about assets • Successful and sustainable asset management requires leadership, organizational alignment, and coordination

[Paradigm Shift in Asset Management]

Source: ch2m (2015), 출처 확인

3.4 Aging Infrastructure

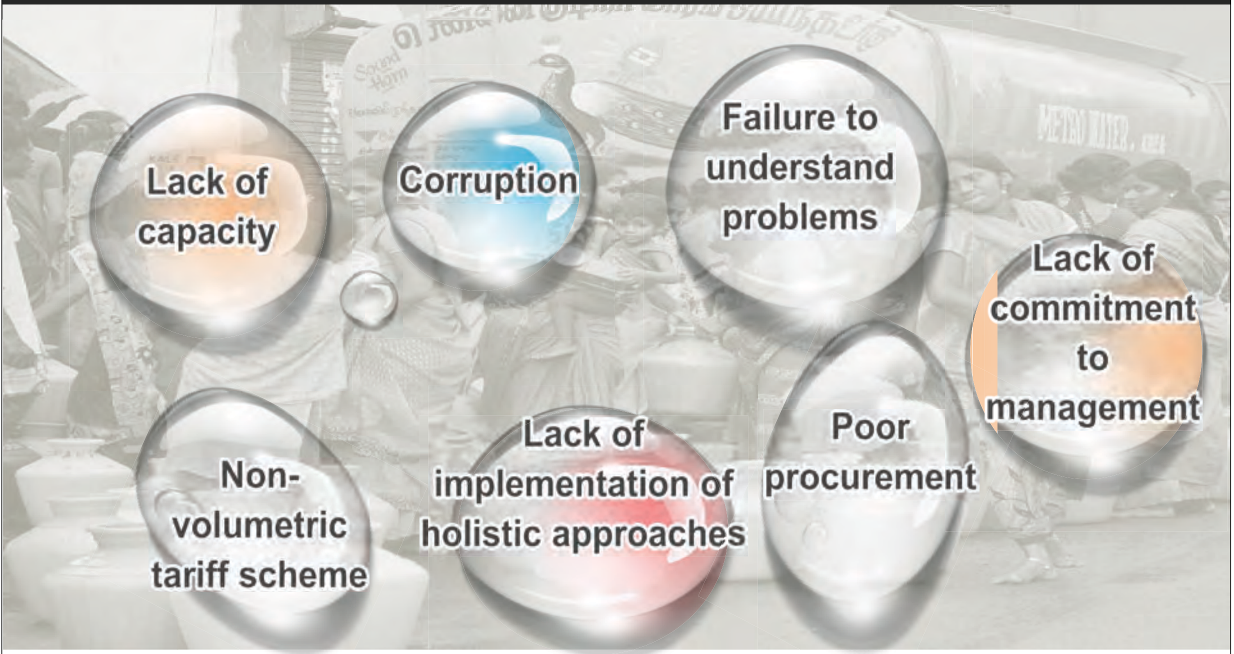
- **(Decision support tool) Water utilities must build their own decision-making tool for asset management, and decision-making tool is composed of four models for degradation, risk, and economic analysis and decision-making**



[Decision Support Tool]

3.5 High Non-revenue Water

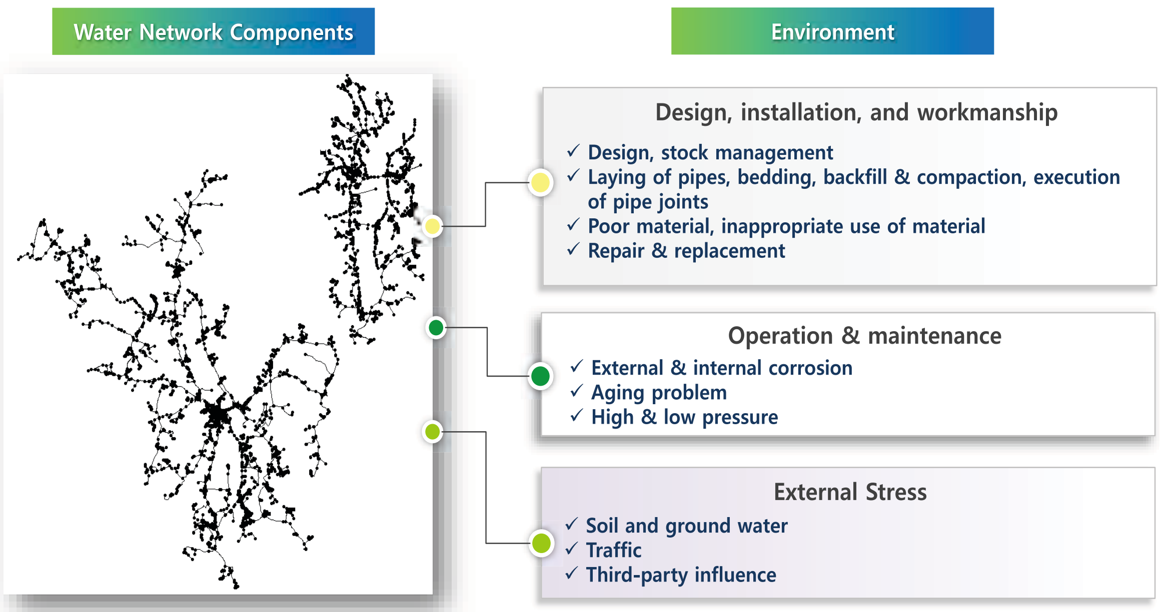
- (Difficulty) Complex reasons can explain the struggle of utilities in controlling NRW



[Challenges in Water Loss Management]

3.5 High Non-revenue Water

- (Causes of real loss) The multitude of active and passive interactions between water network component and their environment frequently lead to damage and leaks



[Causes of Real Losses]

3.5 High Non-revenue Water

- **(Causes of apparent loss) Apparent losses includes meter inaccuracy, data handling error, and unauthorized consumption**

Meter Inaccuracy

- Lack of meter maintenance
- Registering error
- Improper meter selection
- Incorrect installation
- Deterioration

Data Handling error

- Administrative error
- Meter reading error
- Data transfer error
- Distorted customer consumption
- Estimated volume
- Poor customer account management
- Poor billing system

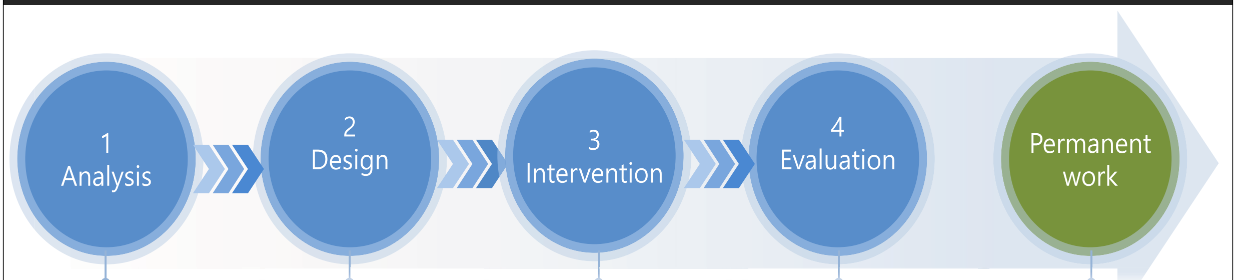
Unauthorized Consumption

- Illegal connection
- Meter by-passing
- Meter tampering
- Theft at hydrants or fountains
- Corruption of meter reader

[Main Causes of Three Apparent Losses Types]

3.5 High Non-revenue Water

- **(NRW control program) The process is composed of four phases, namely, analysis, design, intervention, and evaluation, with permanent work**



1 Analysis
- 1.1 Establishing NRW management and audit teams
- 1.2 Preliminary system diagnosis
- 1.3 Establishing water audit and PIs

2 Design
- 2.1 Setting targets
- 2.2 Selecting interventions
- 2.3 Developing action plans

3 Intervention
- 3.1 Establishing monitoring systems
- 3.2 Establishing information systems
- 3.3 Apparent loss management
- 3.4 DMA establishment and management
- 3.5 Leak detection, location, and repair
- 3.6 Pressure management

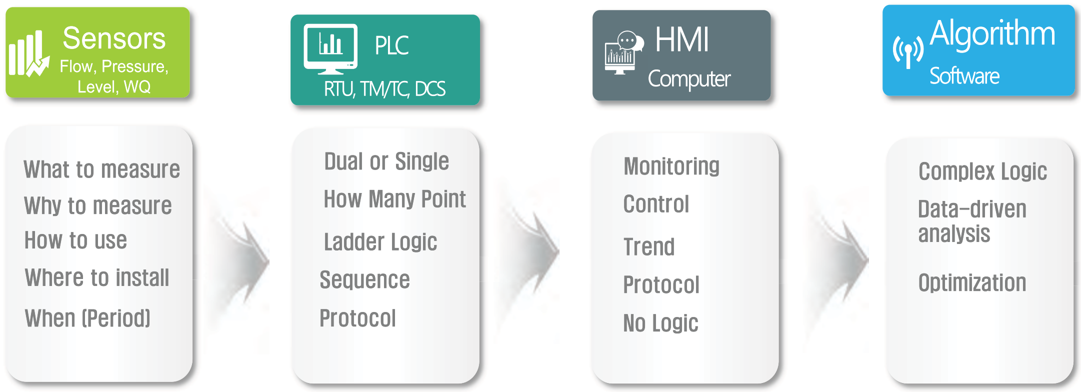
4 Evaluation
- 4.1 Performance assessment

Permanent work
- Organizational change
- Capacity development
- Community awareness, education, and communication

[Process of Water Loss Control Program]

3.6 Poor Data Collection, Storage, and Organization

- **(Poor data management) Data such as system maps, historic records of the equipment, and the performance of instrument are not appropriately collected, stored, and archived**



[Considering Items for Data Management]

3.7 Water Waste

- **(Water Waste) Not only water loss but also water waste is a serious problem if the tariff scheme is not volumetric due to poor metering and IWS**

Water loss

Total water loss pertains to the difference between the amount of water produced and amount billed or consumed

Leakage

Leakage is one of the components of the total water loss in a network and comprises physical losses from pipes, joints, and fittings and from overflowing service reservoirs

Water waste

Deliberate waste (e.g., standpipe vandalism and tap left "open" permanently in areas with intermittent supply to fill vessels when supply returns, which then overflows)

[Definition of Water Loss, Leakage, and Water Waste]

3.8 Low Workmanship

- (Low workmanship) Employees' low technical proficiency due to low staff motivation and training hinders efficient O&M.

[Improper Joint Connection]

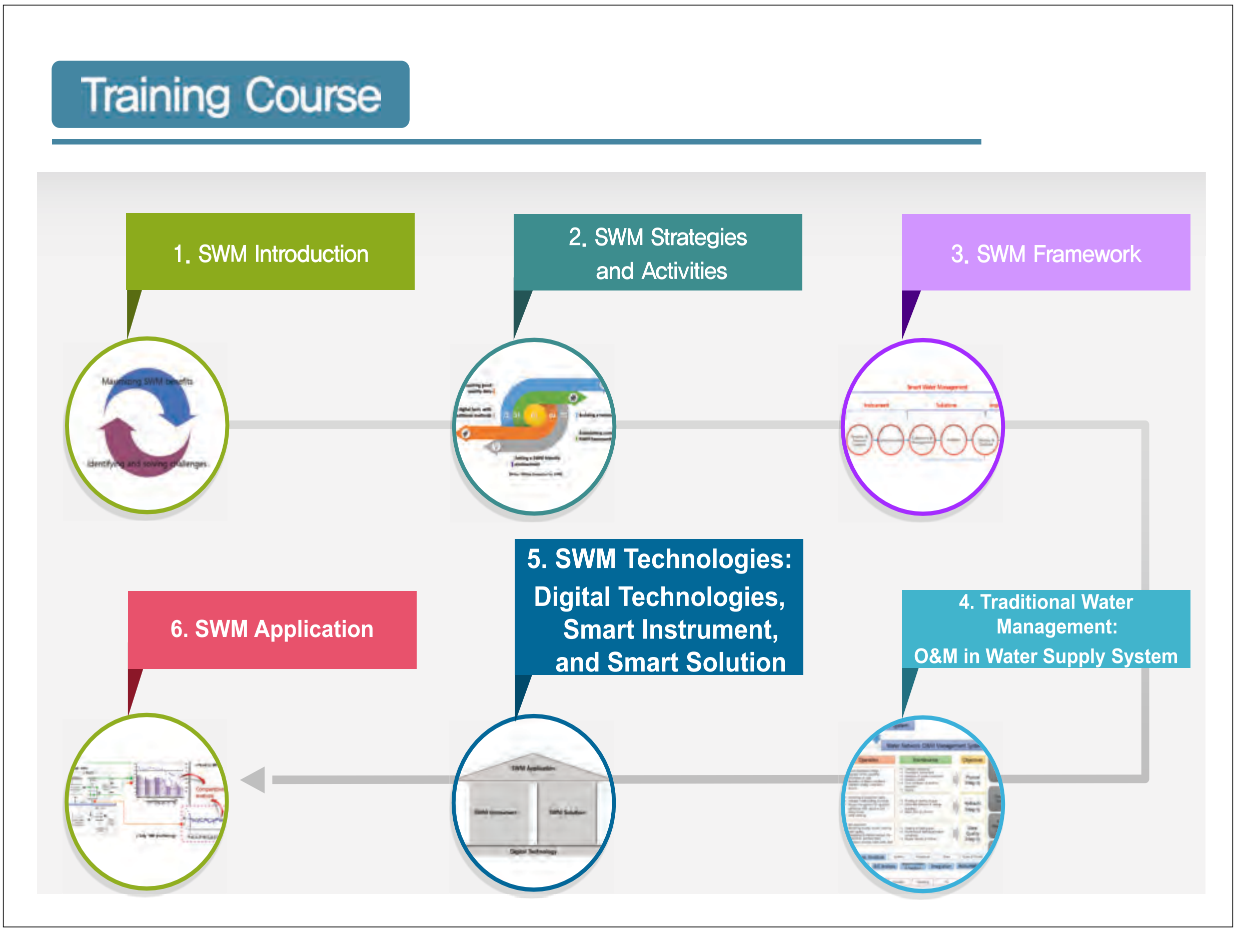
[Improper Repair Using a Wooden Needle]

Thank you very much

SWM Technologies: Digital Technologies, Smart Instrument, and Smart Solution

Smart Water Management


5. SWM Technologies:
Digital Technologies,
Smart Instrument,
and Smart Solution
UNESCO
United Nations Educational, Scientific and Cultural Organization
i-WSSM
International Centre for Water Security and Sustainable Management


Training Course
1. SWM Introduction
2. SWM Strategies and Activities
3. SWM Framework
4. Traditional Water Management: O&M in Water Supply System
5. SWM Technologies: Digital Technologies, Smart Instrument, and Smart Solution
6. SWM Application

Aims & Objectives

- **The aims of the course are to:**

  (1) Provide the concept of digital technologies and examples of smart instruments and smart solutions;

  (2) Enable trainees to adopt and embrace suitable smart instruments and solutions based on planned SWM strategies and activities

- **The objectives are that trainees will understand:**

  (1) The fundamental digital technologies;

  (2) Types and characteristics of SWM instruments;

  (3) Types and characteristics of SWM solutions

Contents

1. Overview

1.1 Backgrounds

1.2 Digital Technology, SWM Instrument, and SWM Solution

1.1 Backgrounds

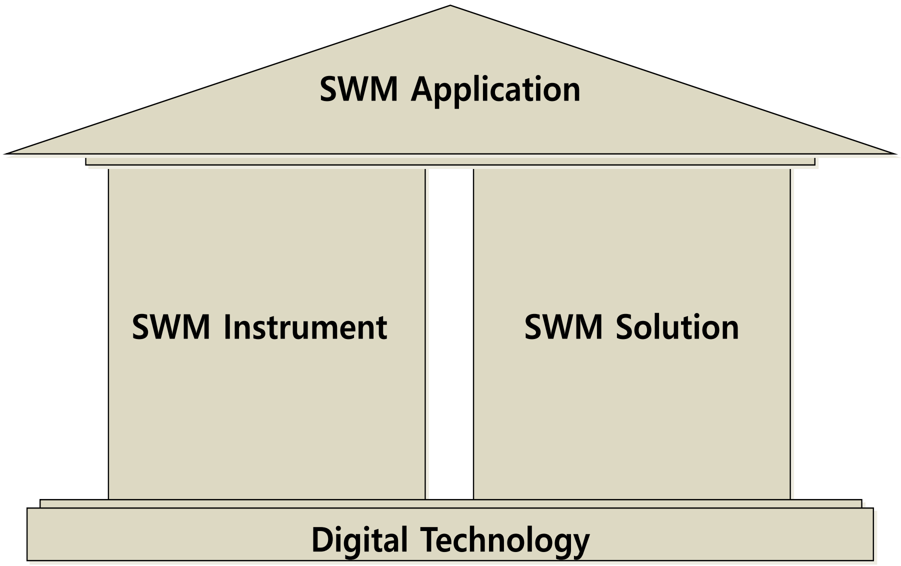
- (Emerging digital technologies) Emerging digital technologies including a host of techniques and methods help water utilities operate with more efficiency and make decisions based upon the scientific evidence

- (Smart technologies for SWM) Smart instrument and solutions for SWM has the potential to be a key game changer to address the water-related challenges and use water more sustainably

- (Optimizing a given opportunity) As time passes and the pressure increase, water utilities should embrace change and make the most of the given opportunities

1.2 Digital Technology, SWM Instrument, and SWM Solution

- (Structure) Smart technologies such as instrument and solution are developed based on digital technology, and O&M efficiency can be improved using smart technologies



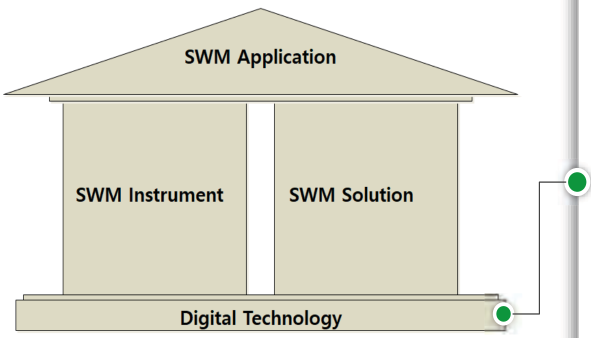
[SWM instrument, Solution, and Application on the Basis of Digital Technology]

2. Digital Technology

2.1 Digital Technologies
2.2 Internet of Things (IoT)
2.3 Information & Communication Technology (ICT)
2.4 Cloud
2.5 Artificial Intelligence (AI)
2.6 Big Data
2.7 Virtual and Augmented Reality (VR & AR)

2.1 Digital Technologies

- (Digital technology) There are promising digital technologies such as IoT, ICT, Cloud, AI, Big data, VR & AR, and Robots in water sector to optimize operational efficiency, increase work productivity, and create additional value

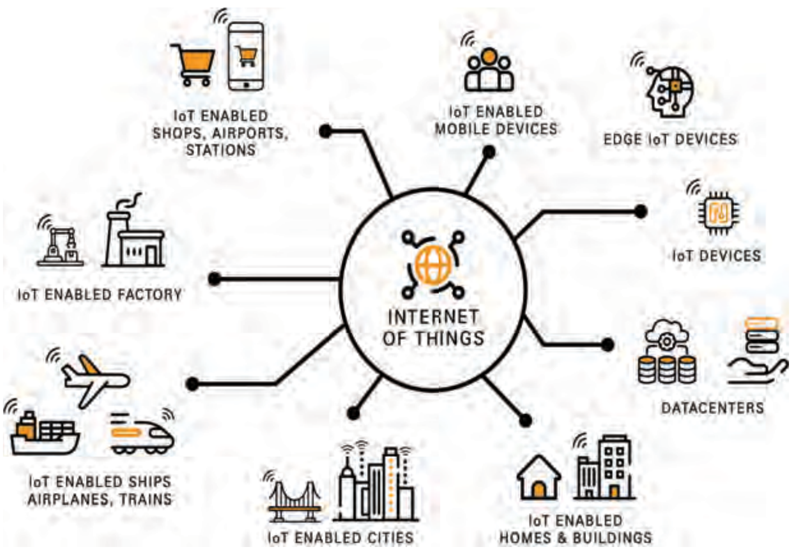


- Internet of Things (IoT)
- Information and Communication Technologies (ICT)
- Cloud
- Artificial Intelligence (AI)
- Big Data
- Virtual and Augmented Reality (VR & AR)
- Robots
- Etc.

[Kinds of Digital Technologies]

2.2 Internet of Things (IoT)

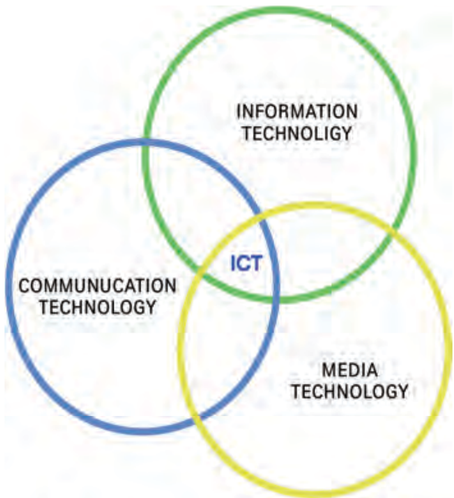
- (IoT) IoT refers to a number of objects (e.g., IoT applications, networked devices, industrial equipment) that can share data with other objects through the Internet



[Connections in Internet of Things]

2.3 Information & Communication Technology (ICT)

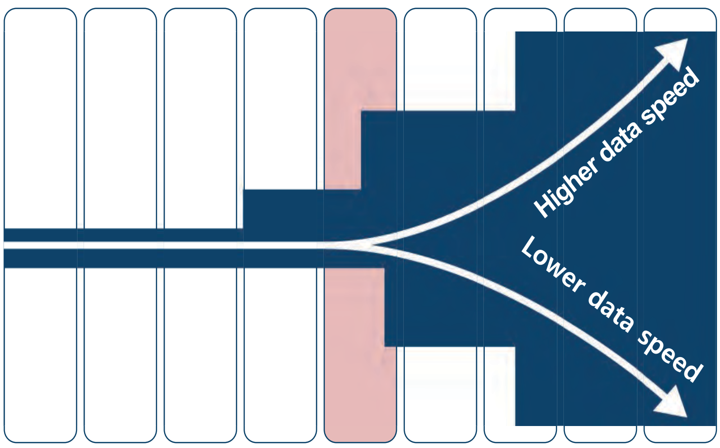
- (ICT) Information and communication technology refers to all technologies necessary for storage, processing, and management as well as exchanging information



[Schematic of Information & Communication Technology]

2.3 Information & Communication Technology (ICT)

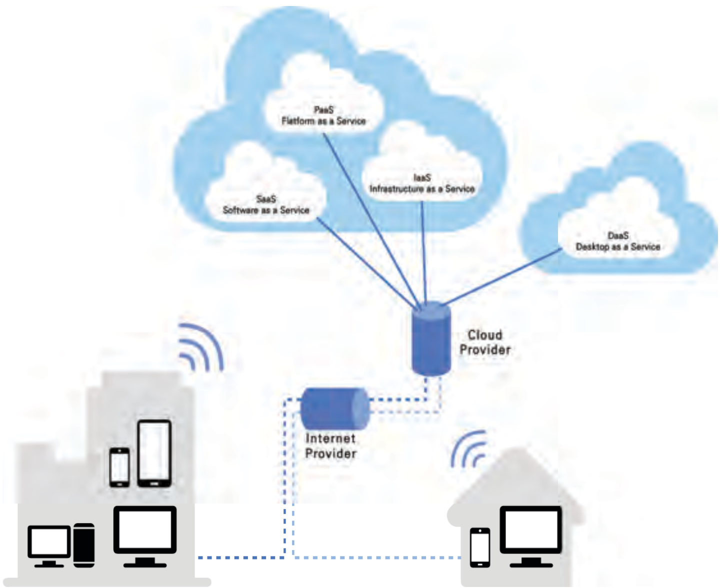
- (Development Trends) High-speed and large-capacity traffic processing technologies suitable for multimedia service and low-speed and small-volume traffic processing technologies suitable for IoT have developed simultaneously



[ICT Technologies Development Trend]

2.4 Cloud

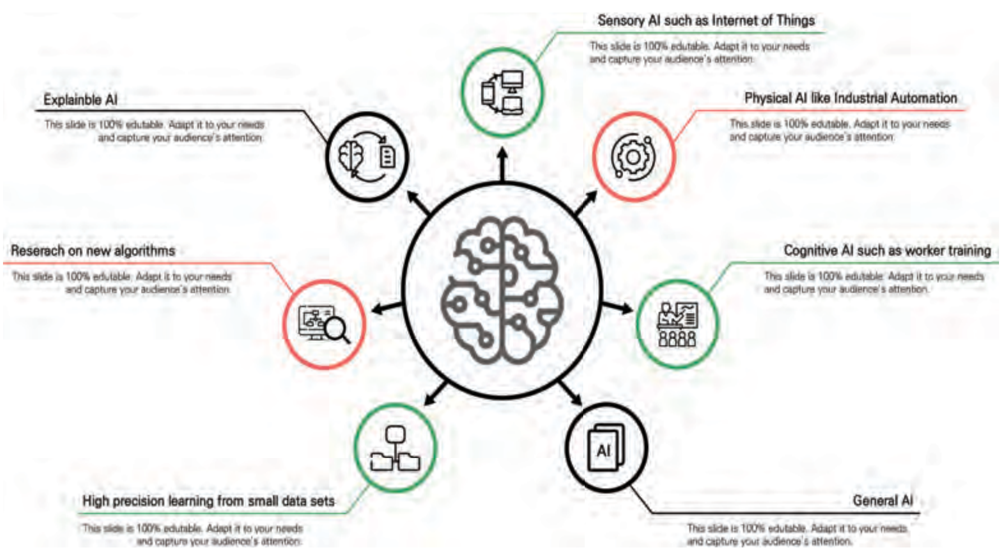
- (Cloud) Cloud refers to servers that can be accessed through the Internet and software and databases that operate on these servers



[How Cloud Computing Works]

2.5 Artificial Intelligence (AI)

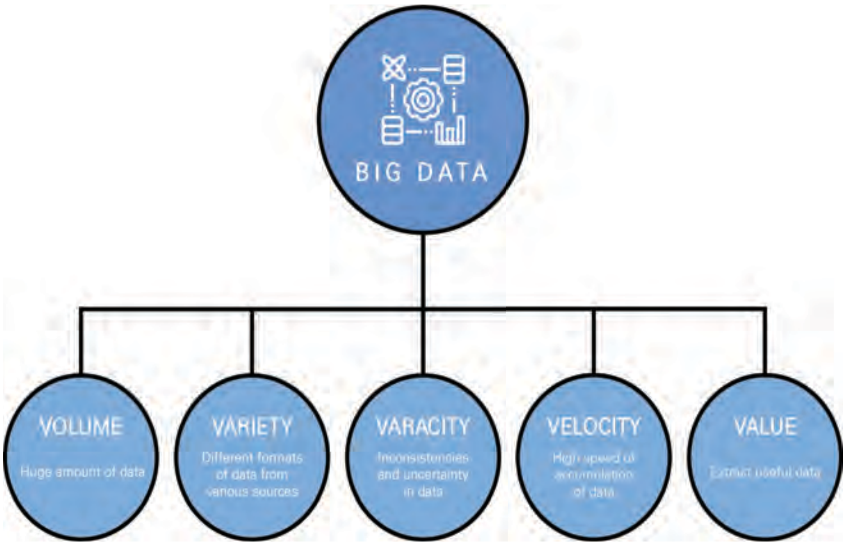
- (AI) Artificial Intelligence (A.I) refers to an artificial implementation of some or all of human intellectual abilities, or the ability to be thought so



[Core Areas of Artificial Intelligence]

2.6 Big Data

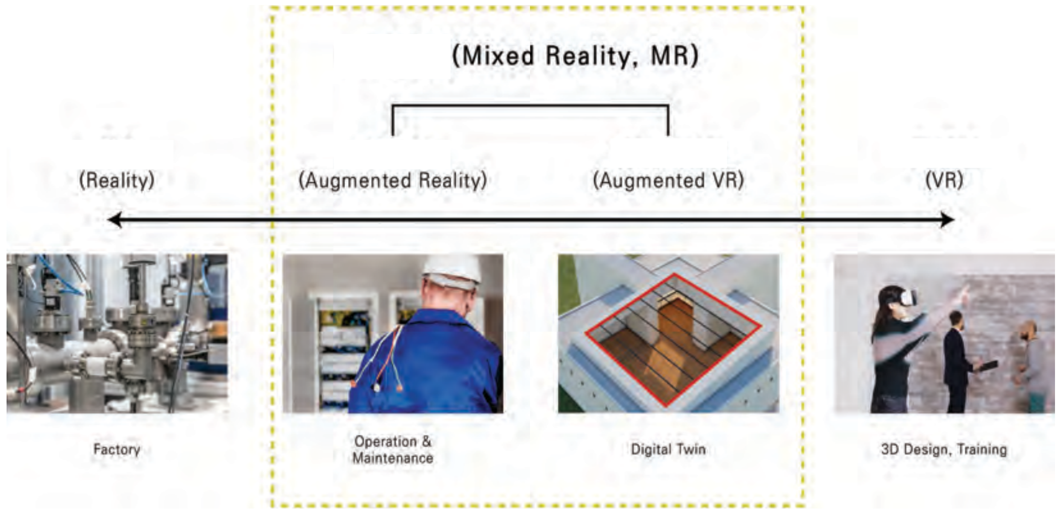
- **(Big data) Big data means data with a very large, fast growth rate, and wide variety as well as its processing methods that allow analyzing information in a distributed manner**



[Characteristics of Big Data]

2.7 Virtual and Augmented Reality (VR & AR)

- **(VR & AR) Virtual reality (VR) and augmented reality (AR) technologies based on computer graphics has the potential to support decision making in the field**



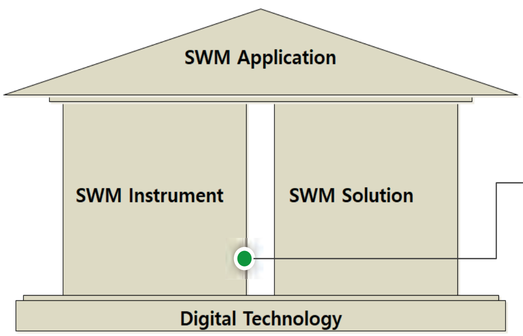
[The relationship between reality, AR, and VR]

3. SWM Instrument

3.1 SWM Instruments
3.2 SCADA
3.3 Smart Meter, AMI, and AMR
3.4 Leakage Detection Equipment

3.1 SWM Instruments

- (SWM instrument) Based on digital technologies, various SWM Instruments such as SCADA, smart meter, level detection equipment, and water quality equipment are being developed and applied

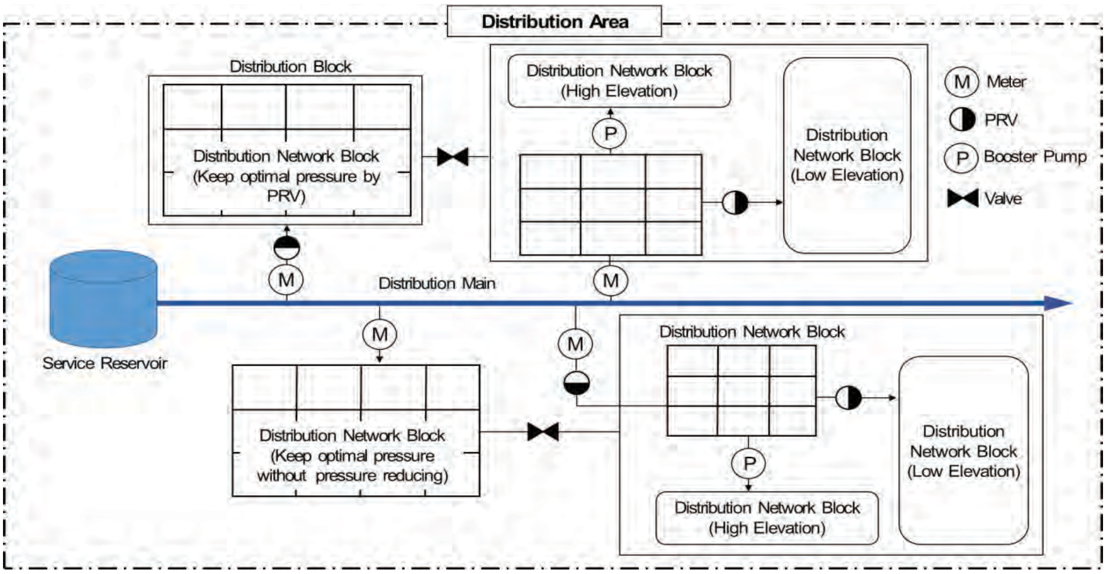


- SCADA
- Automatic Meter Reading (AMR), Smart Meter(SM), Advanced Metering Infrastructure (AMI)
- Leakage Detection Equipment
- Water Quality Management Equipment
- Information Sharing Equipment
- Etc.

[Types of SWM Instrument]

3.2 SCADA

- (SCADA) Supervisory Control And Data Acquisition (SCADA) is a system for remote monitoring and control of industrial infrastructure or facility processes

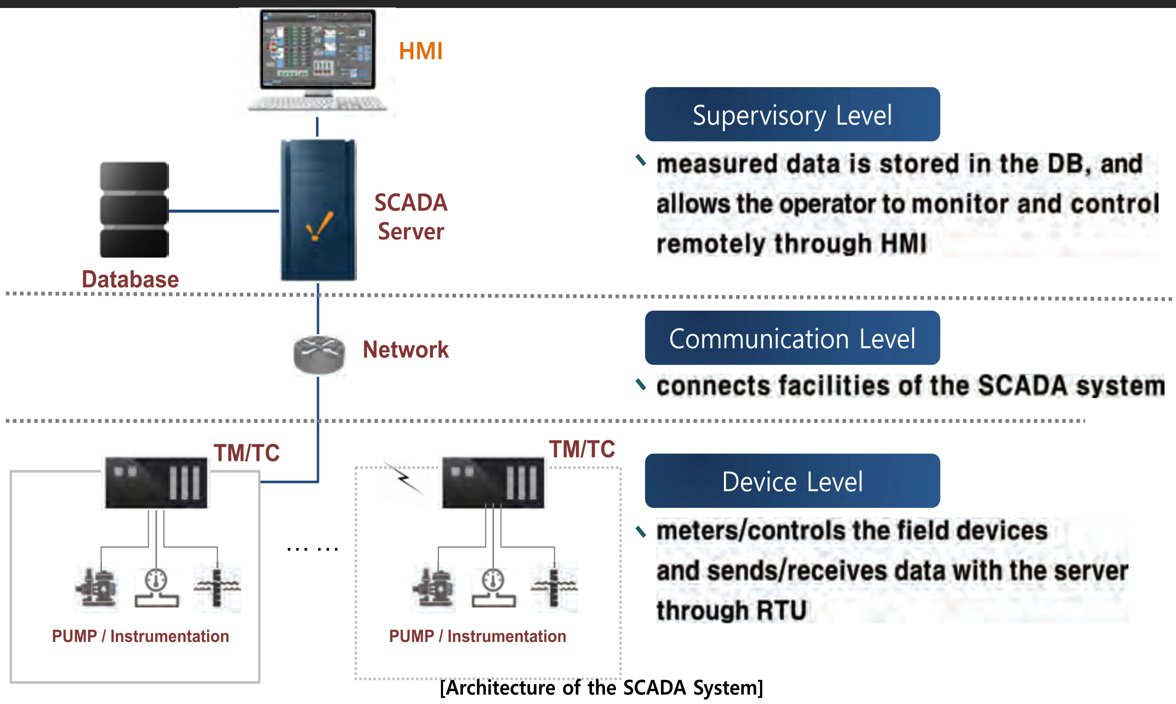


[Water Supply System Monitoring Schematic]

Source: K-water

3.2 SCADA

- (Structure) SCADA system is composed of device, communication and supervisory level



[Architecture of the SCADA System]

3.2 SCADA

- **(Function) Archiving(logging), trending, access control, automation, warning, and report generation are the main functions of SCADA**

01

LOGGING, ARCHIVING

- Storing data in a fixed format form
- Logging and archiving data (parameters, period of time, etc.)
- Logging user's actions with a ID

02

TRENDING

- Providing real-time and trend history information
- Multiple trending charts are displayed in real-time
- Charts contain multiple pens, zooming, scrolling, panning, hairline

03

ACCESS CONTROL

- Users are organized in groups by a set of allocated privileges
- Privileges include access and process parameter writings
- Some can have access to limited graphics and functions

[Main Functions of SCADA #1]

3.2 SCADA

04

AUTOMATION

- Actions can be initiated automatically under an occurrence of event
- Actions are based on initially set parameters

05

WARNING

- Warning is based on settings (e.g. threshold) and situations
- Waring include audio, video, TTS(text to speech), e-mail, and SMS

06

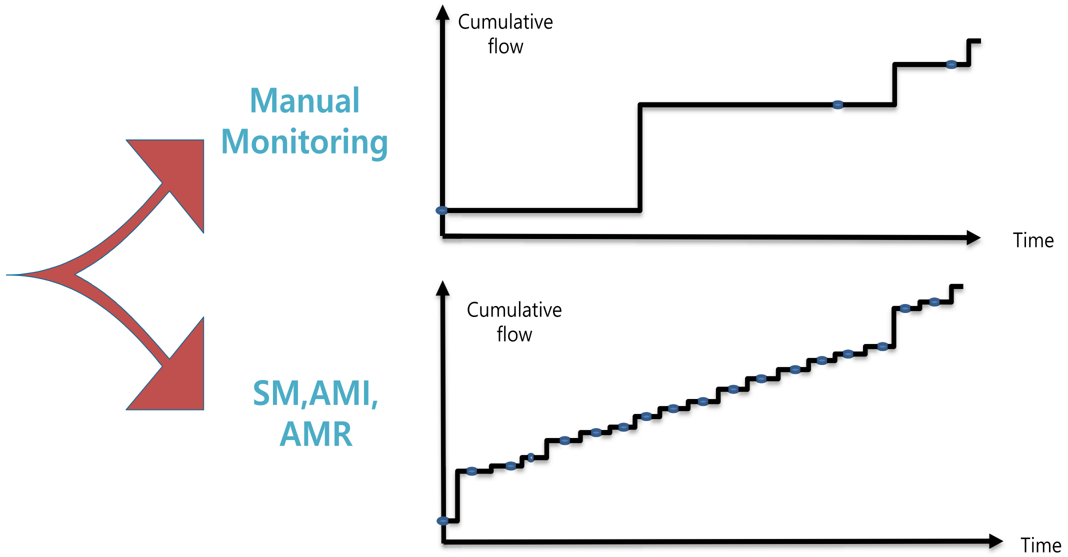
REPORT GENERATION

- Reports can be created using SQL type queries to the RTDB or logs
- Automatic generation, printing and archiving of reports is possible

[Main Functions of SCADA #2]

3.3 Smart Meter, AMI, and AMR

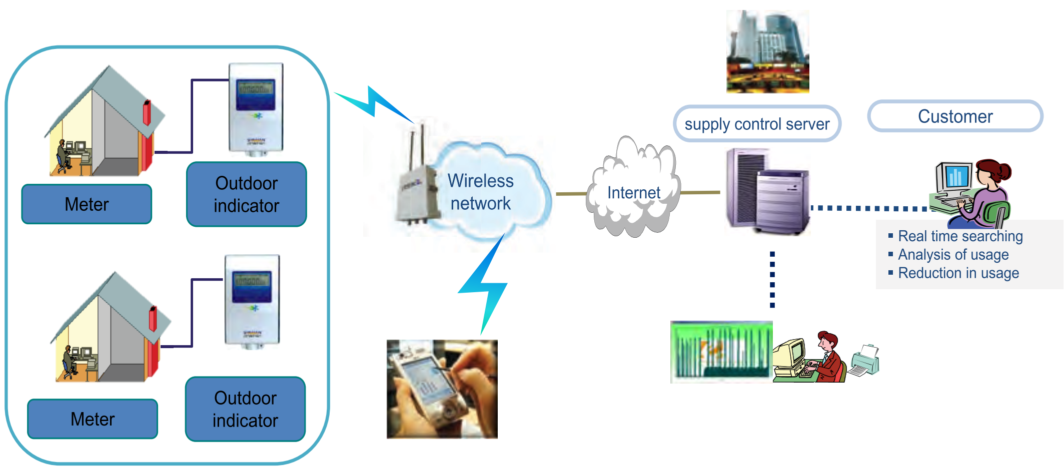
- (Smart meter, AMI, AMR) Smart meter, advanced metering infrastructure (AMI), and Automatic meter reading (AMR) are the devices where real-time data (e.g., flow, pressure, water quality) sensing and transmitting are available



[Manual Monitoring vs. SM, AMI, AMR]

3.3 Smart Meter, AMI, and AMR

- (Structure) Smart water metering consists of smart meter(sensor, register, meter interface unit, AMI module), IoT network, TCP/IP Internet, data server, and monitoring & control system



[The Structure of Smart Metering System]

3.3 Smart Meter, AMI, and AMR

- **(Function) The widespread deployment of smart meter, AMI or AMR facilitate daily operation, detecting and preventing events, and demand management**

01

DAILY OPERATION IMPROVEMENT

- Storing data in a fixed format form optimizing resource use (e.g., chemical use for water treatment)
- Saving the energy with controlling pumping schedule and pressure at critical point

02

DETECT AND PREVENT DETRIMENTAL EVENTS

- Providing early alarming of unusual events such as pipe burst, high water consumption, water discoloration events.
- Alert home owners and utilities when water quality standards are not being met

03

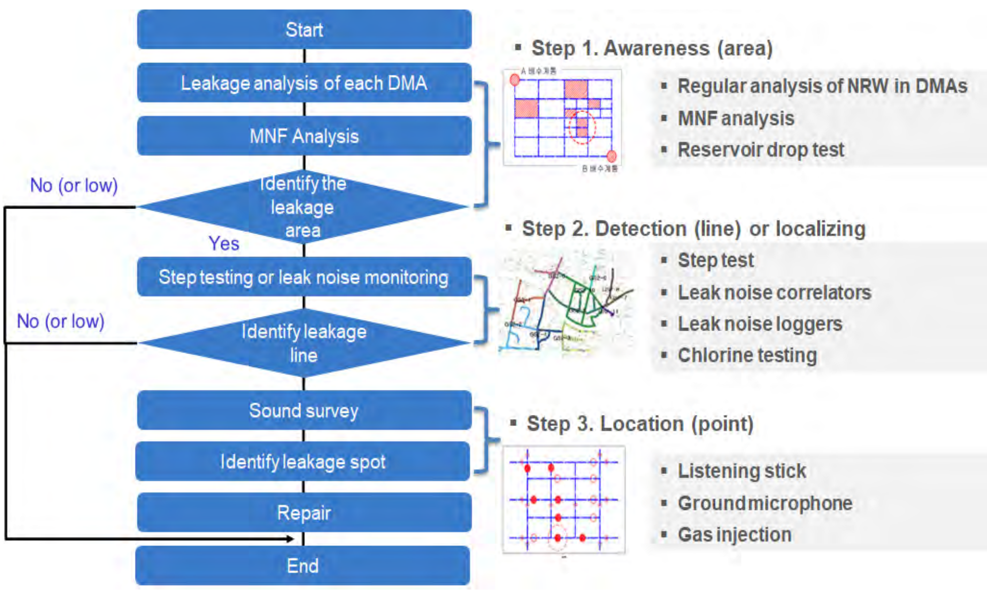
DEMAND MANAGEMENT

- Recording customer water usage, providing a clear picture of water consumption and conveying data to both consumer and utility
- helping in making decisions regarding intervention policies, pricing strategies, and setting of water usage reduction targets

[Main Functions of Smart Meter, AMI and AMR]

3.4 Leakage Detection Equipment

- **(Leakage management process) Leakage amounts in the water network can be reduced through leakage recognition and repair**



[Leakage Management Procedure]

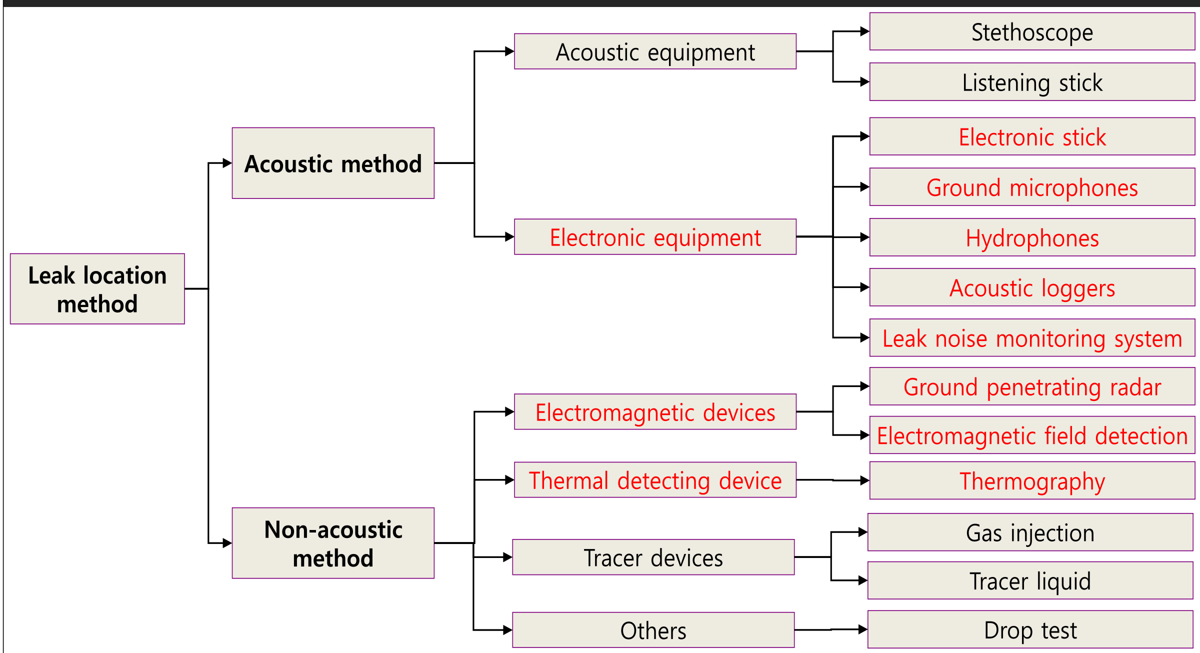
Source: K-water

3.4 Leakage Detection Equipment

- **(Leakage control policy) As part of the strategy implementation, the policy aspect of leakage management can be classified into two operational policies as follows:**
  - Passive leakage control (PLC)
  - Active (proactive) leakage control (ALC)
- **(PLC) PLC pertains to reacting to reported bursts or drops in pressure, which are typically reported by customers or noted by the utility staff while implementing duties apart from leak detection**
- **(ALC) ALC is an intervention method for counteracting real loss. A water utility deploys funds, personnel, and technical equipment to actively detect and repair unreported leaks**
- **(Combined with awareness) ALC is cost effective in certain cases but should not be undertaken in a blanket fashion but rather in a targeted fashion, where specific problem areas are firstly identified (e.g., MNF analysis)**

3.4 Leakage Detection Equipment

- **(Smart equipment) With traditional leak detection equipment, several types of smart leak location equipment have been adopted**



[Traditional and Smart Leak Detection Equipment]

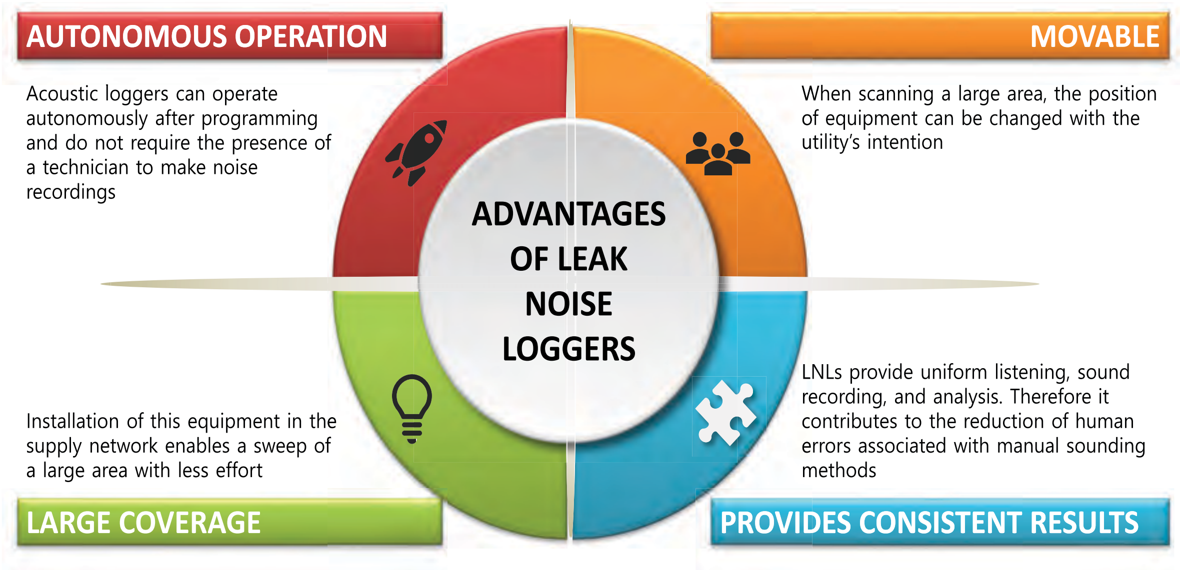
3.4 Leakage Detection Equipment

- **(Leak noise logger or acoustic logger) The reading noise from logger indicates the existence of leakage in the vicinity around the installation site, which is considered suspicious and, thus, subject to a detailed inspection using another type of leak detection equipment**

[Leak Noise Logger (Acoustic Logger)]

Source: Seoyong

3.4 Leakage Detection Equipment



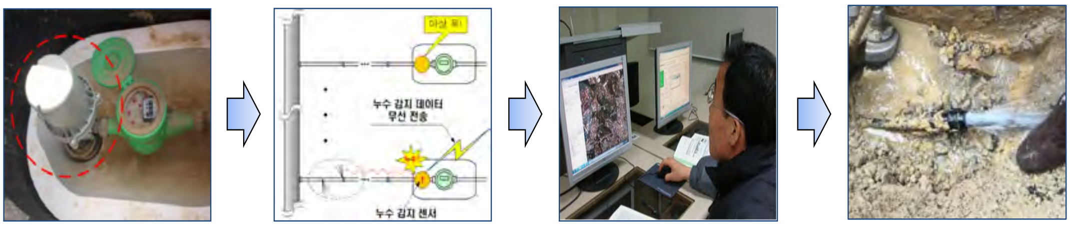
[Advantages of Leak Noise Logger]

3.4 Leakage Detection Equipment

- **(Leak noise monitoring system) Leak noise monitoring system aims for automatic monitoring and data collection with cost-effective, wireless, and movable noise loggers**

[Installing a Noise Logger on a Valve or Meter]

Courtesy of USOL

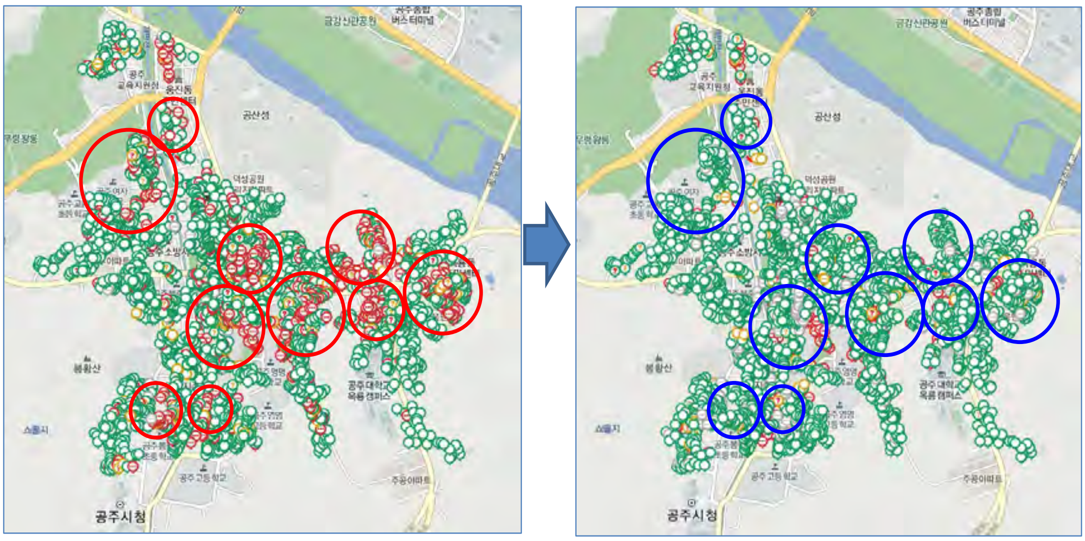


(a) Installation　(b) Detection　(c) Monitoring　(d) Pinpointing and Repair

[Operating Process]

Source: USOL

3.4 Leakage Detection Equipment



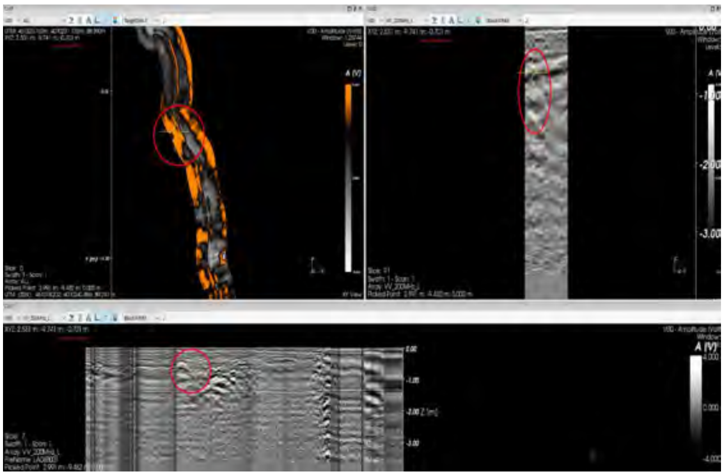
< Aug 15, 2015 >　< May 8, 2016 >

[System Monitoring and Repair Result]

Source: USOL

3.4 Leakage Detection Equipment

- (Ground penetrating radar) The ground penetrating radar operates on the principle of emitting a radar pulse through an antenna into the ground



[GPR Results]

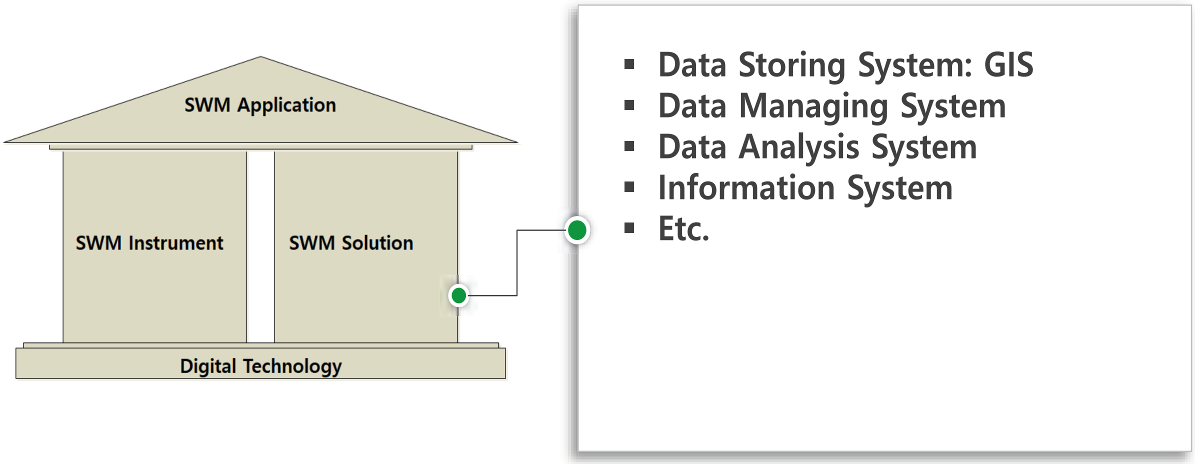
Source: K-water

4. SWM Solution

4.1 SWM Solutions
4.2 GIS-based Integrated Information System
4.3 Data Analysis System

4.1 SWM Solution

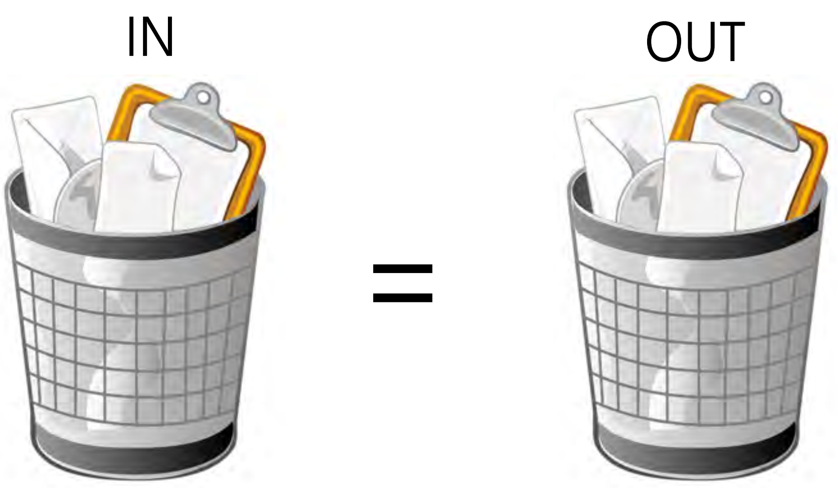
- (SWM solution) A digital solution can transform data into valuable insights and even instructions for moving water utilities' actions to a more proactive approach



[Types of SWM Solution]

4.2 GIS-based Integrated Information System

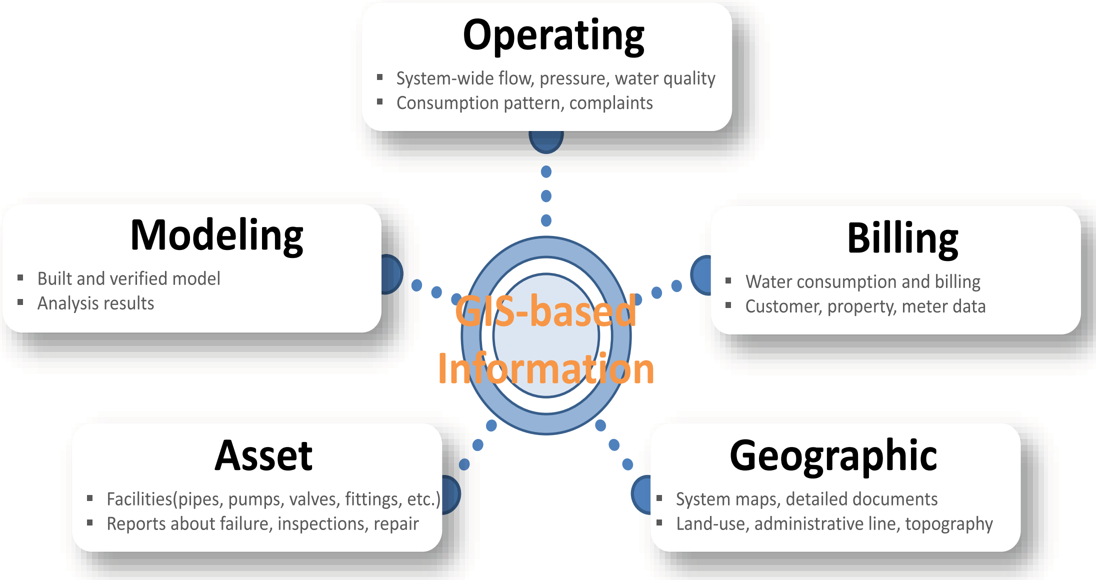
- (Importance) Smart solutions highly rely on data, so water utilities needs precise integrated information system which allows them to carry out their work efficiently



[Garbage In Garbage Out]

4.2 GIS-based Integrated Information System

- (Structure) The GIS-based integrated information system generate or capture operating, modeling, asset, billing and geographic data and manage how the data are shared and used



[The Structure of GIS-based Integrated Information System]

4.2 GIS-based Integrated Information System

- (Function) GIS-based integrated information system has six main functions supporting a specific organization level

01 OFFICE AUTOMATION SYSTEM (OAS)

- Executing office works
- Supporting official activities at every organizational level

02 KNOWLEDGE WORK SYSTEM (KWS)

- Promoting the creation of knowledge
- Making sure that knowledge and technical skills are proper integrated into the business

03 MANAGEMENT INFORMATION SYSTEM (MIS)

- Support the planning, controlling, and decision-making functions of middle managers

[Main Functions of Information System #1]

4.2 GIS-based Integrated Information System

04

DECISION SUPPORT SYSTEM (DSS)

- Executing a specific managerial task or problem
- Helping managers to make semi-structured decisions

05

EXECUTIVE SUPPORT SYSTEM (ESS)

- Helping in decision-making at the top level of an organization

06

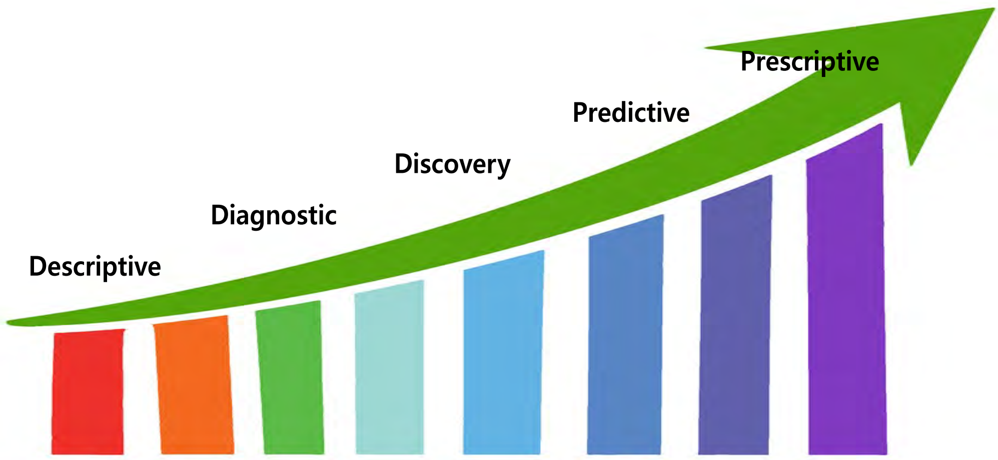
TRANSACTION PROCESSING SYSTEM (TPS)

- Performing its daily business operations

[Main Functions of Information System #2]

4.3 Data Analysis System

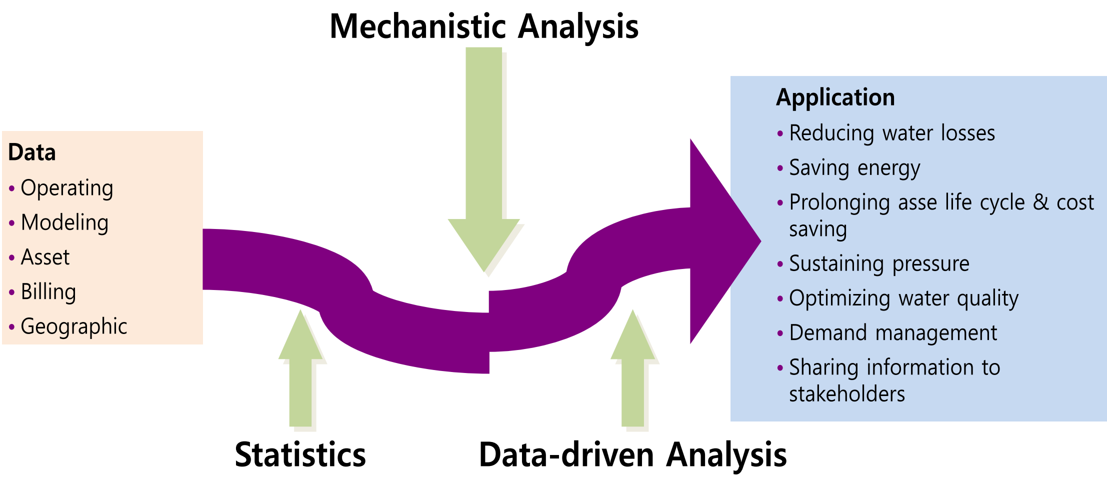
- (Importance) Using various big data acquired from SWM instrument, water utilities can perform various and more accurate analysis for hindsight, insight, and foresight purpose



[The Five Purpose of Data Analysis System]

4.3 Data Analysis System

- **(Pipeline) Data analysis system include analysis techniques (statistics, mechanistic analysis, data-driven analysis) and provides actionable insight using acquired data**



[Steps of a Data Analysis Pipeline in SWM]

Thank you very much

SWM Application

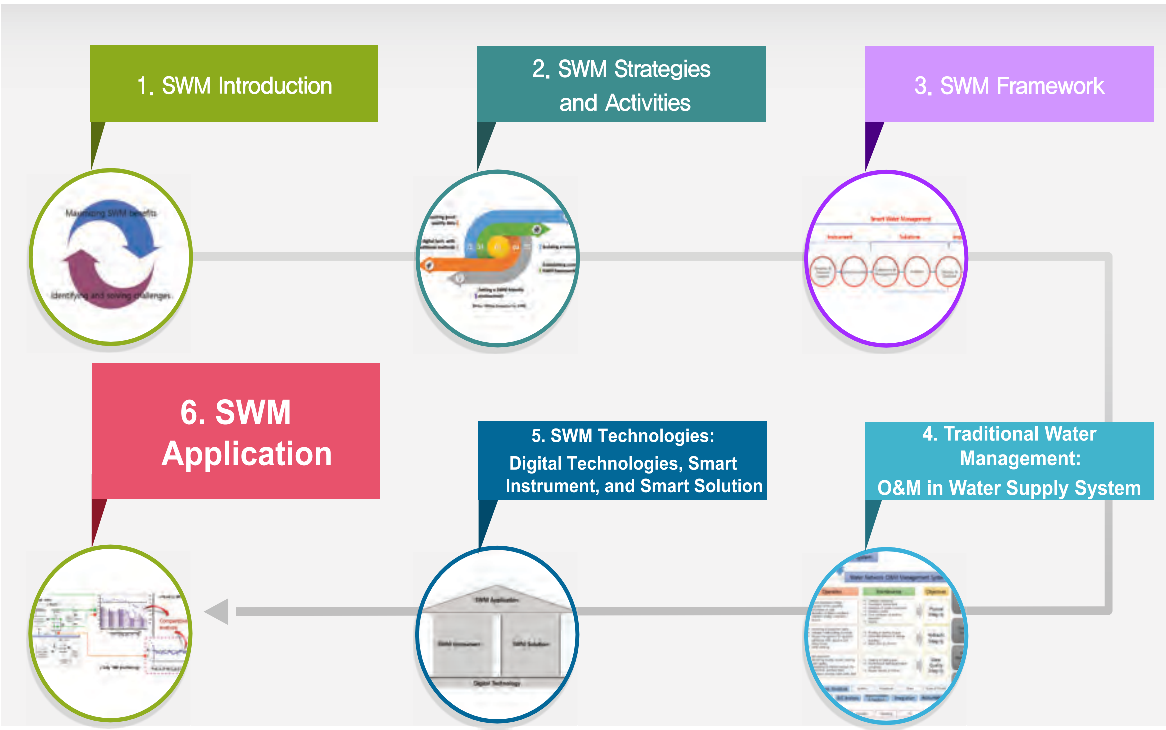
Smart Water Management

6. SWM Application

United Nations Educational, Scientific and Cultural Organization

i-WSSM International Centre for Water Security and Sustainable Management

Training Course



Aims & Objectives

- **The aims of the course are to:**
  - (1) Provide the concept of SWM application and example of smart water loss management;
  - (2) Enable trainees to integrate traditional methods with smart instruments and solutions for SWM application
- **The objectives are that trainees will understand:**
  - (1) SWM application;
  - (2) Examples of SWM application;
  - (3) Smart water loss management

Contents

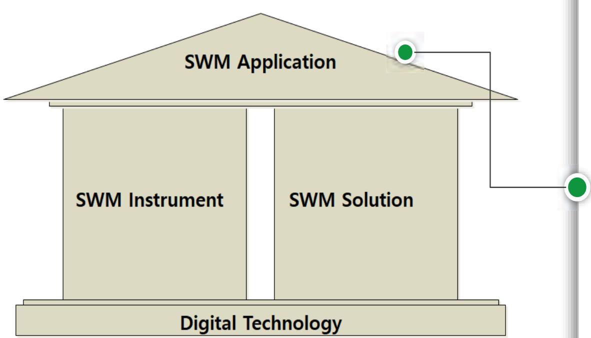
1. SWM Application
2. Integrating Traditional Methods with Smart Instrument and Solution
3. Example #1 : Traditional Water Loss Management
4. Example #1 :Implementing SWM Instrument and Solutions for Water Loss Managmement

1. SWM Application

1.1 SWM Application
1.2 Examples of SWM Application

1.1 SWM Application

- (SWM application) With SWM instrument and solution, water utilities can improve their O&M efficiency such as reducing water losses, saving energy, prolonging asset life cycle, optimizing water quality, etc.



- Reducing water losses
- Saving energy
- Prolonging asset life cycle and cost saving
- Sustaining pressure
- Optimizing water quality
- Demand management
- Dissemination of information to stakeholders

[Types of SWM Solution]

1.2 Examples of SWM Application

Reducing Water Losses	Saving Energy
▪ Performing Near real-time water audit to identify and quantify water loss ▪ Enhancing leak aware, detection, and location process	▪ Remotely optimizing the network pressure and pumping schedule ▪ Reducing the amount of water needed to be treated and delivered ▪ Reducing the water waste and the water demand from consumer

1.2 Examples of SWM Application

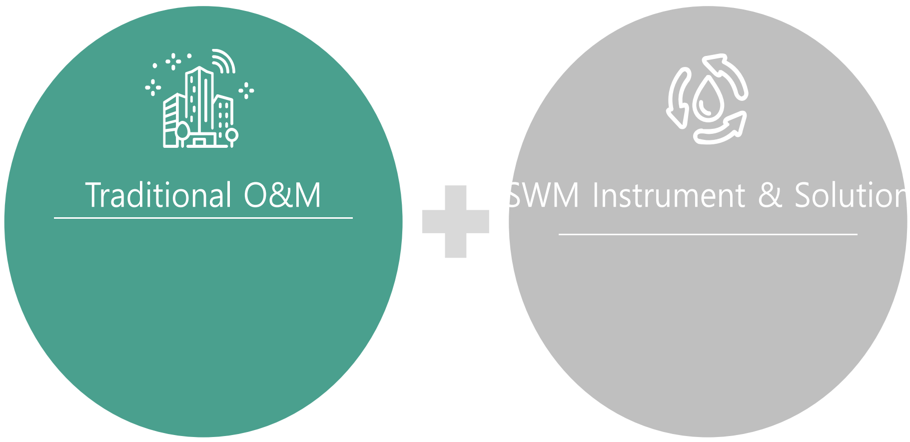
Prolonging asset life cycle & cost saving	Optimizing water quality
▪ Developing a failure model by using monitoring data from pumps, pipelines, valves, and reservoirs ▪ Planning and scheduling repair, rehabilitation and replacement of the asset in a timely manner	▪ Establishing WQ warning system with online WQ monitoring (e.g., free chlorine, TOC, pH, conductivity, and turbidity) ▪ Equipping remotely controlled isolation drain valves

2. Integrating Traditional Methods with Smart Instrument and Solution

2.1 Integration
2.2 SWM Implementation

2.1 Integration Traditional O&M with Smart Instrument & Solution

- (Key factor) Suitably integrating traditional O&M methods with smart instruments and solutions is the key factor to success in SWM application



[Integrating Traditional O&M methods with Smart Instruments and Solutions]

2.2 SWM Implementation

- **(Implementation) SWM project should be implemented based on the existing O&M (system, guidelines, regulations, know-how) to improve O&M efficiency**

Existing O&M Process

- Systems
- Guidance materials
- Regulations
- Know-how (Rules of thumb)

Implementing SWM

- Identification
- Selection
- Design
- Construction
- Monitoring
- Evaluation

Improving Efficiency

- Effectiveness
- Efficiency
- Accountability
- Transparency
- Fairness
- Participation

2.2 SWM Implementation

- **(Procedure) The current system analysis, establishing objectives & selecting methods, design & construction and monitoring/evaluation process is required for the implementation of SWM**

Procedure	Details
Status analysis	- Update the existing basic data - Analysis of current system problems and major issues through system diagnosis (hydraulics, water quality, facilities) using basic data * IWS, high NRW, water quality, energy efficiency * aged infrastructure, poor data management
Establishment of SWM purpose and application method	- Establishment of customized SWM application plan based on current status analysis - Holistic approach with various SWM technologies according to purpose, not single SWM technologies
Design & Construction	- Based on reliable modeling and experience, the appropriate location and quantity of SWM technology is determined to maximize efficiency and enhance operation
Monitoring & Performance Evaluation	- Establishment and evaluation of performance indicators

3. Example #1 : Traditional Water Loss Management

3.1 Classification of Water Loss
3.2 Concept of Water Loss Management
3.3 Water Loss Control Program
3.4 Analysis Phase
3.5 Design Phase
3.6 Intervention Phase
3.7 Evaluation Phase
3.8 Permanent Work

3.1 Classification of Water Loss

- **Terms: Standardized terminologies are a precondition for water loss management**
  - Terminologies are well explained and defined in Standard Definitions for Water Losses (Pearson, 2019)

Water loss
Total water loss pertains to the difference between the amount of water produced and amount billed or consumed

Leakage
Leakage is one of the components of the total water loss in a network and comprises physical losses from pipes, joints, and fittings and from overflowing service reservoirs

Water waste
Deliberate waste (e.g., standpipe vandalism and tap left "open" permanently in areas with intermittent supply to fill vessels when supply returns, which then overflows)

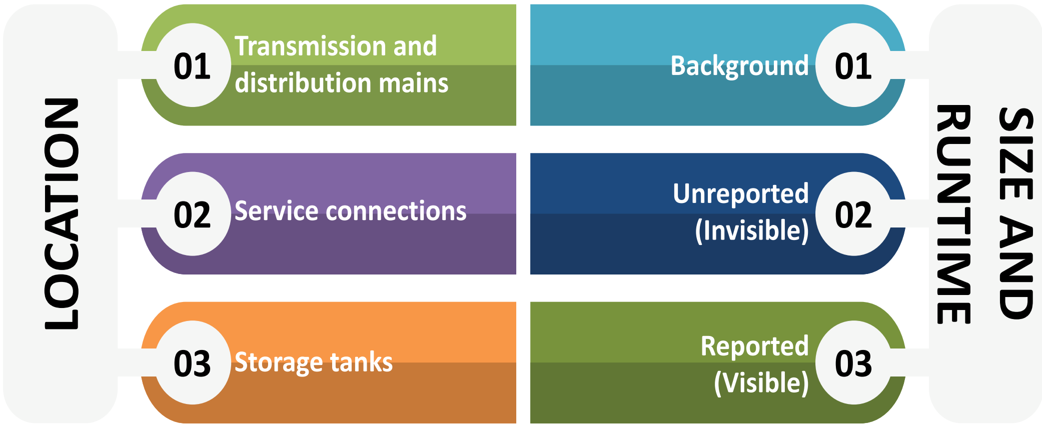
Real loss
Real loss denotes loss from the pressurized system and from the utility's service reservoirs to the point of supply

Apparent loss
Apparent loss includes all types of inaccuracies associated with customer metering, data handling errors, and unauthorized consumption

[Definition of Terminologies in Water Loss Management]

3.1 Classification of Water Loss

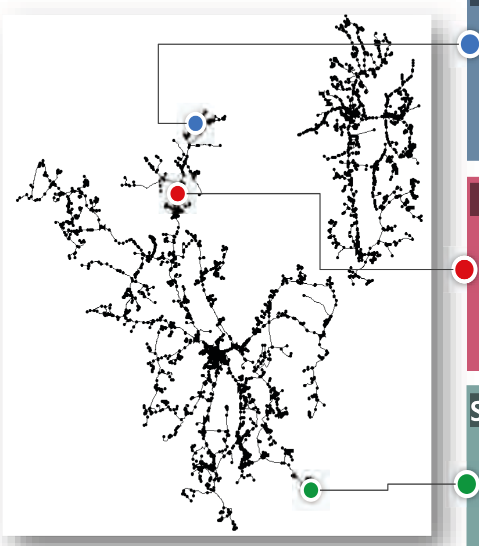
- **Classification of real loss: Real losses can be classified according to location within the system or size and runtime**



[Classification of Real Loss]

3.1 Classification of Water Loss

- **Location: This classification is typically used when the IWA water balance is calculated**



Storage tanks
- Water loss is caused by deficient or damaged level controls
- Seepage may occur from masonry or concrete walls that are not watertight
- Water losses from tanks are frequently underestimated and, although easy to detect, repair is elaborate and expensive

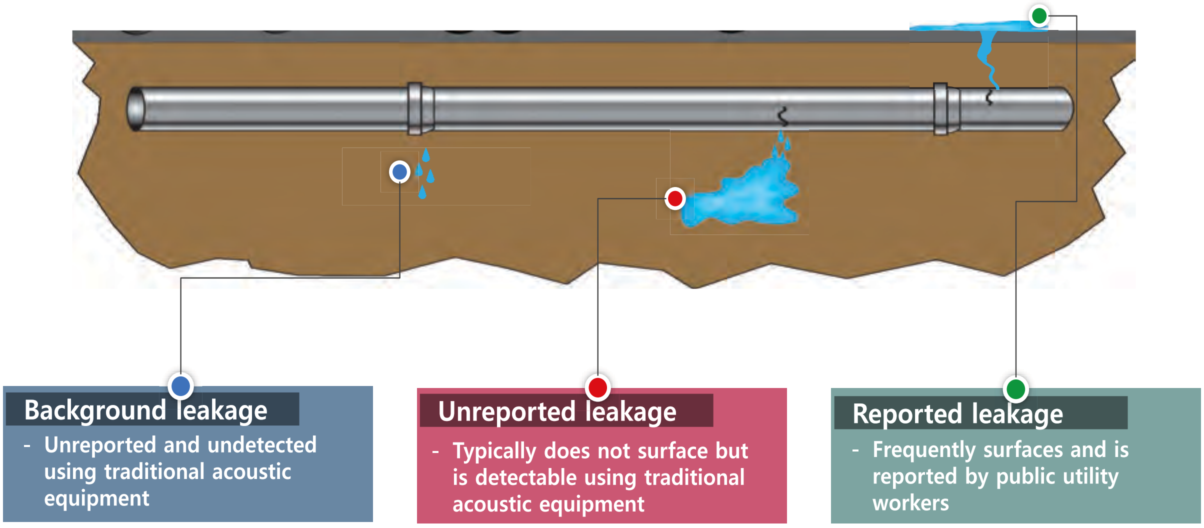
Transmission and distribution mains
- Water loss may occur in pipes (bursts due to extraneous causes or corrosion), joints (disconnection and damaged gaskets), and valves (operational or maintenance failure)
- Water loss typically reaches medium to high flow rate and short to medium runtime

Service connections
- Water loss is in the form of leakage from service connections up to the point of the customer meter
- Service connections are oftentimes referred to as the weak points of water supply networks because their joints and fittings exhibit high failure rates

[Classification of Real Loss Based on Location]

3.1 Classification of Water Loss

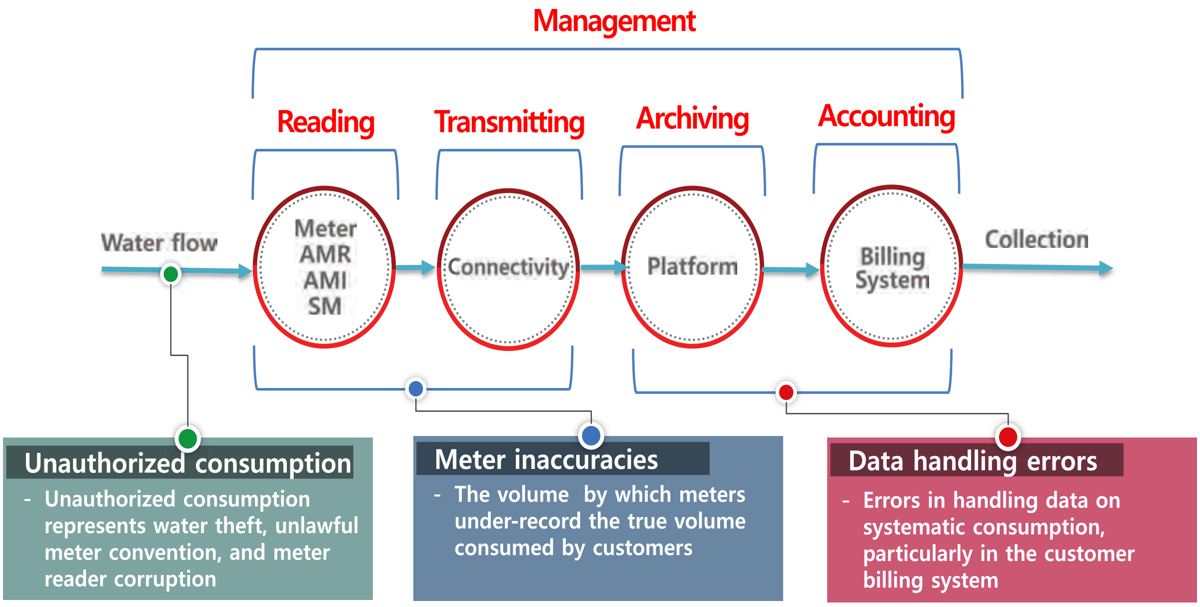
- Size and runtime: This classification is used when minimum night flow analysis is implemented



[Classification of Real Loss based on Size and Runtime]

3.1 Classification of Water Loss

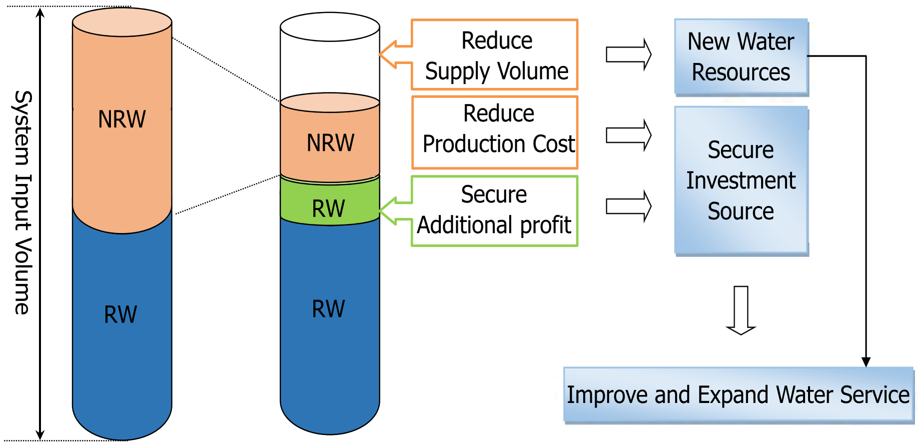
- Classification of apparent loss: Apparent loss consists of three main elements, namely, meter inaccuracies, data handling errors, and unauthorized consumption



[Classification of Apparent Loss]

3.2 Concept of Water Loss Management

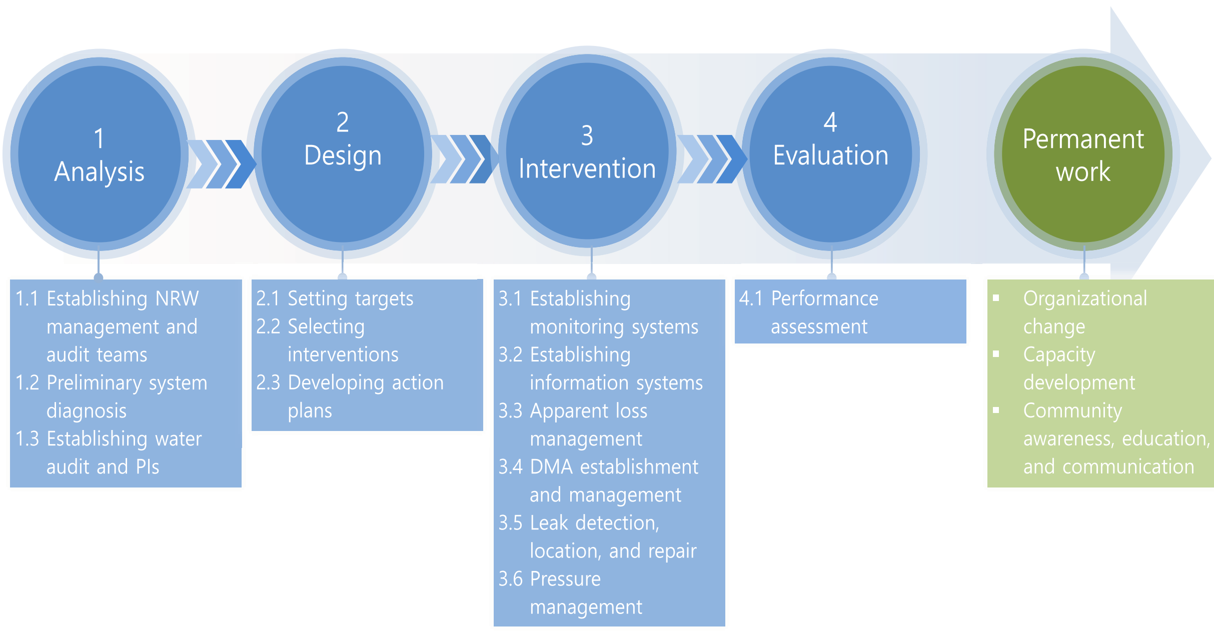
- **Water loss management: By reducing NRW, water utility services can reduce the supply volume and secure additional profit**
  - Reducing excessive real water loss results in the greater amount of water available for consumption and postpones the need for investing in new sources
  - Similarly, reducing commercial losses generates additional revenues with a short payback period



[Concept of Water Loss Management]

3.3 Water Loss Control Program

- **The process is composed of four phases, namely, analysis, design, intervention, and evaluation, with permanent work**



[Process of Water Loss Control Program]

3.4 Analysis Phase

- **The main objectives of the analysis phase are assessing the distribution, metering, and billing operations and determining the volume of water loss and its location**

[Analysis Phase in the Water Loss Control Program]

3.4 Analysis Phase: NRW Management and Audit Teams

- **Audit team: The NRW audit team is not responsible for any physical activities to reduce NRW but should be dedicated to assessing all departments involved with NRW activities**
  - An independent team should be established to audit progress because the process is a utility-wide undertaking

01 ESTABLISHING ANNUAL TARGETS

- The NRW audit team will establish annual targets for each department using one or more of the indicators

02 MONITORING MONTHLY PROGRESS

- The team will monitor progress on a monthly basis

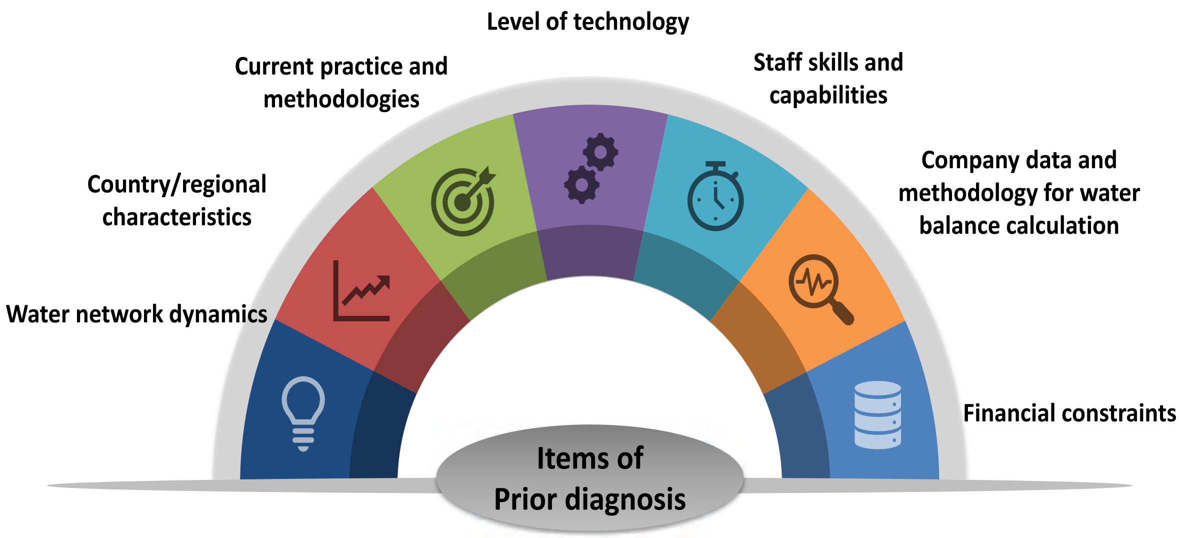
03 MANAGING GOVERNANCE

- The head of the NRW audit team will support the chair by providing technical details and progress reports

[Main Tasks of the Audit Team]

3.4 Analysis Phase: Preliminary System Diagnosis

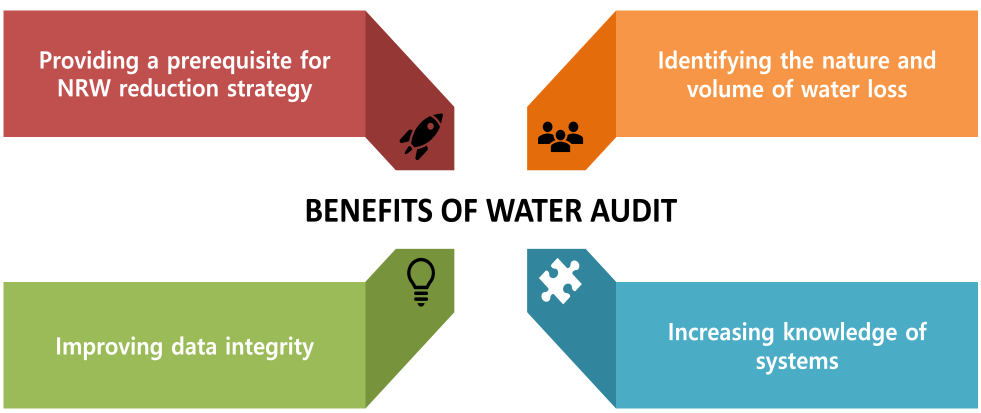
- **Importance of preliminary system diagnosis: Prior diagnosis is necessary to determine a starting point**
  - Current water loss must be understood and assessed using a diagnostic approach before an appropriate water loss reduction program can be developed



[Main Items of Preliminary System Diagnosis]

3.4 Analysis Phase: Water Audit and Performance Assessment

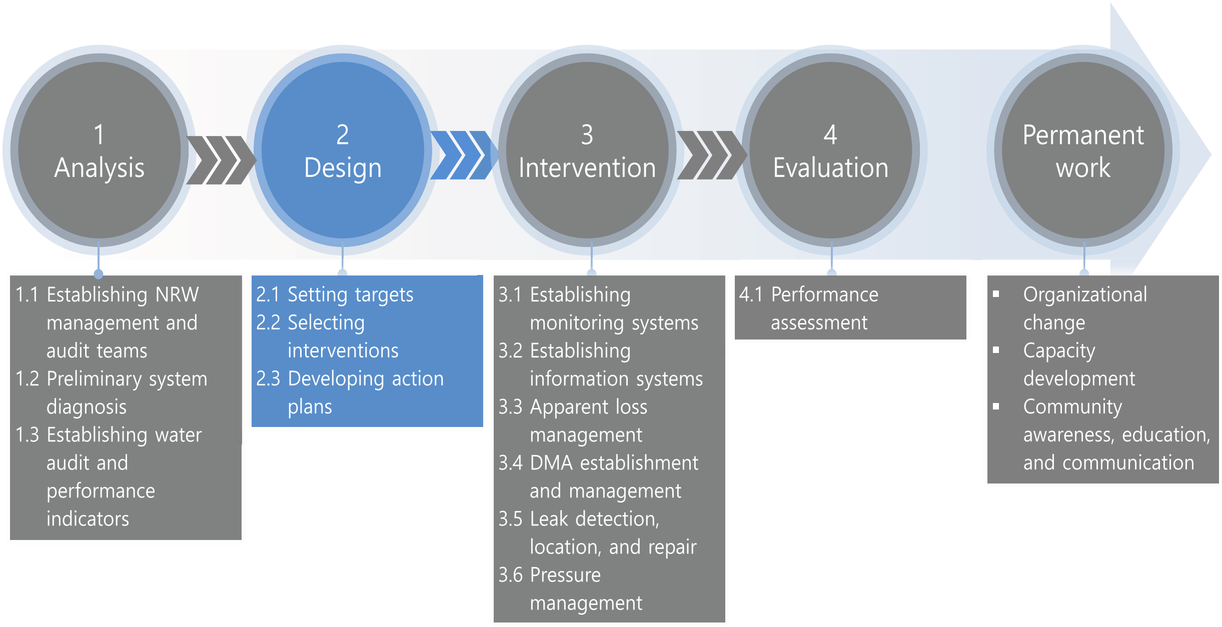
- **Importance: Water audit is the foundation and critical first step in establishing an effective water loss management program**



[Benefits of Water Audit]

3.5 Design Phase

- **(Objects) The main objects of design phase should be to develop a holistic NRW master plan based on the results of analysis phase and setted targets**



[Design Phase in Water Loss Control Program]

3.5 Design Phase: Setting Targets

- **Rough targets: At the early stages of the water loss control program, targets are mainly based on assumptions, which will later be supplemented by accurate information collected throughout the process**
  - The strategy development team should firstly set a company-wide target for NRW reduction by considering the other goals or policies of the utility's that may complement or conflict with NRW reduction
- **Methods: The economic level of leakage (ELL) or target-setting guidelines can be used in formulating a leakage reduction target**
- **Factors in consideration: The target level will be a compromise between a series of competing factors, such as available budget, human resources, technical feasibility, time constraints, and even political considerations**

3.5 Design Phase: Selecting Interventions

- **Counteractive measures: A set of specific counteractive measures is available for each component of NRW**

- Deploying all meters
- Appropriately installing meters
- Meter testing programs
- Meter rotation programs
- Managing large consumers' meters
- Establishing meter DB

- Identifying and reducing illegal connections
- Preventing illegal connections
- Tackling meter by-passing
- Addressing meter tampering

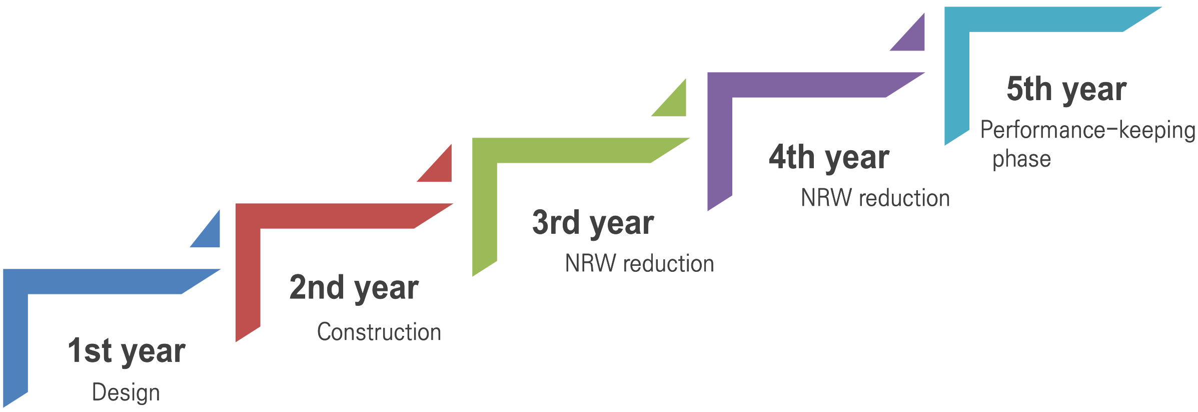
- Analyzing and modifying the billing system
- Training meter readers
- Detecting unregistered consutomers
- Changing MMr to AMR

- Establishing monitoring systems
- Establishing and managing DMA
- Leak detection, location, & repair
- Pressure management

[Specific Counteractive Measures]

3.5 Design Phase: Developing Action Plans

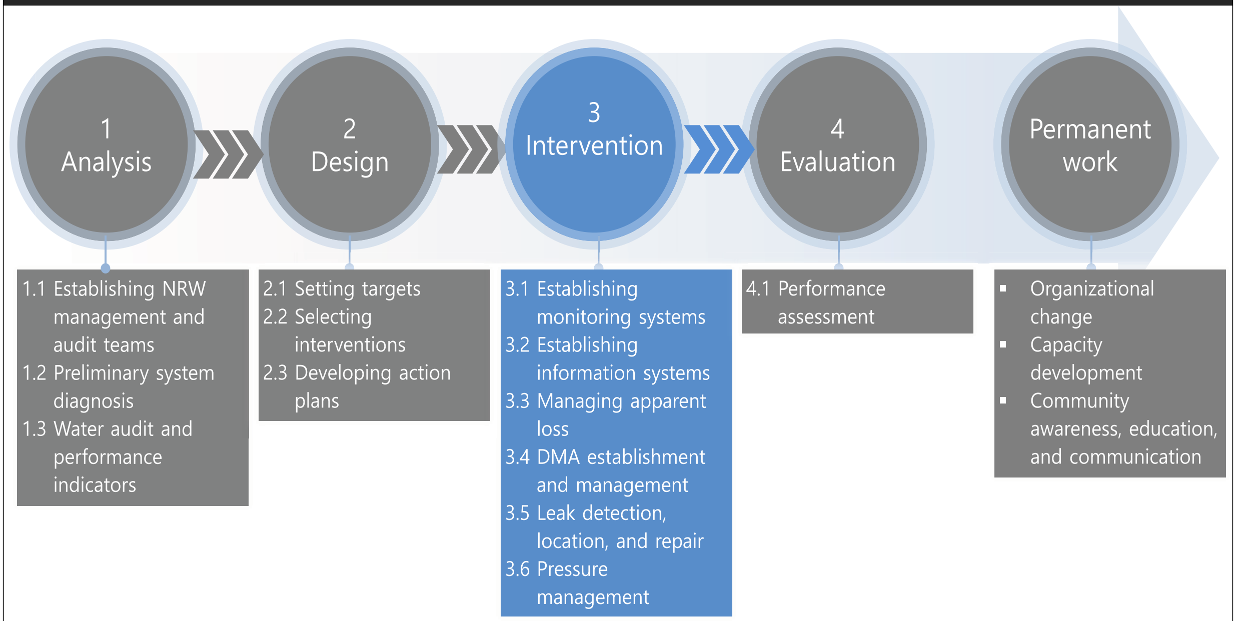
- **After understanding the components of water loss and their relative significance, action plans can be developed to address each of the causes of the loss**
  - Training and skill transfer are essential components of the program to ensure the sustainability of good leakage management



[Phases of Action Plan]

3.6 Intervention Phase

- **The main objectives of the intervention phase is selecting interventions and their order on the basis of budget constraints, public benefit, and priority of other scheduled capital improvements**

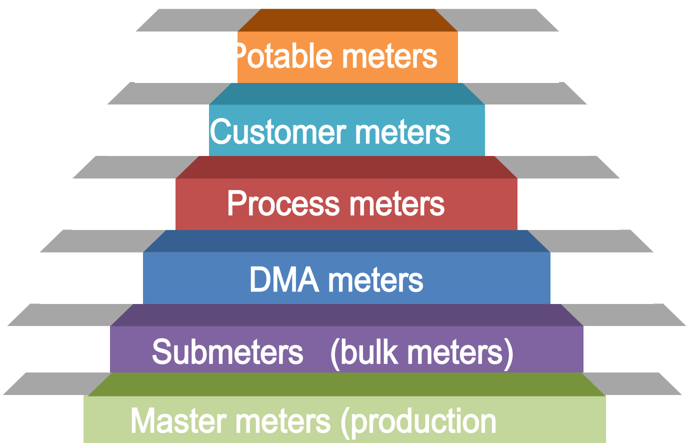


[Intervention Phase in the Water Loss Control Program]

3.6 Intervention Phase: Establishing Monitoring Systems

- **Requirements: Suitable selection and field application with appropriate installation are key conditions for the positive performance of meters**

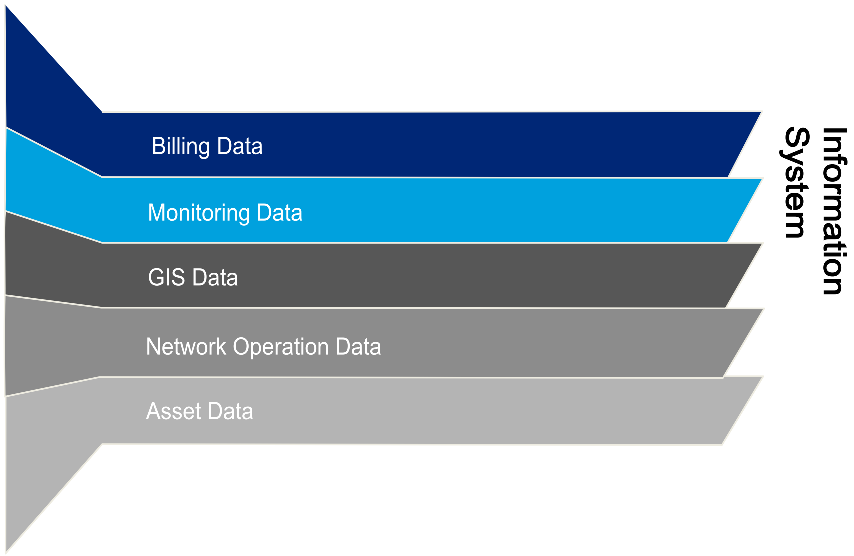
- **Flow monitoring: The most common scheme for monitoring any water system that aims to locate potential leakage is based on flow meters or water meters located from the source to customers**



[Hierarchy of Flow Metering]

3.6 Intervention Phase: Establishing Information Systems

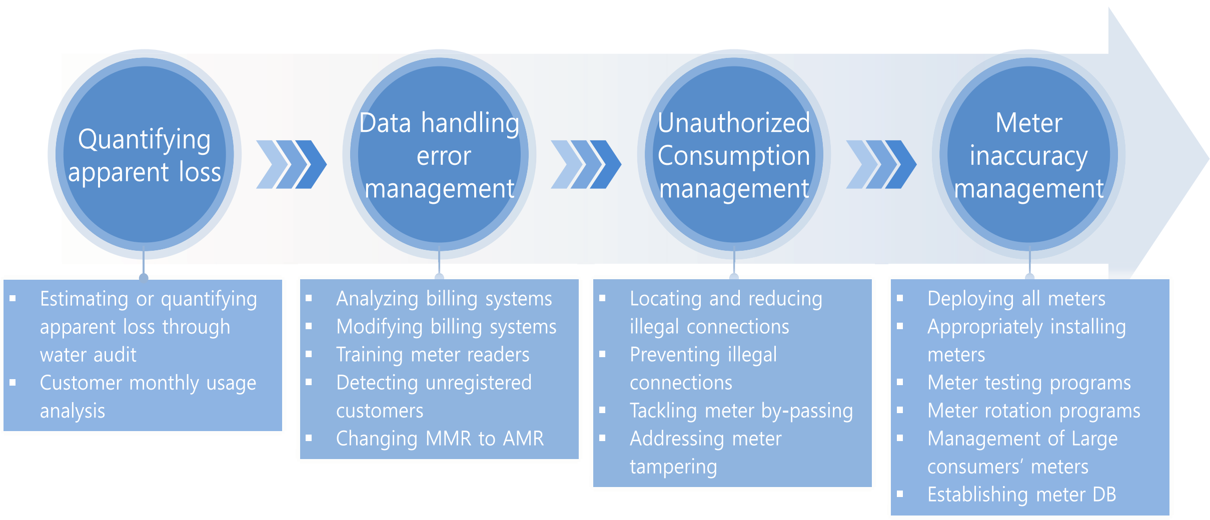
- **Components of information systems: Water utilities use several types of information systems with numerous interactions between various information systems**



[Components of Information Systems]

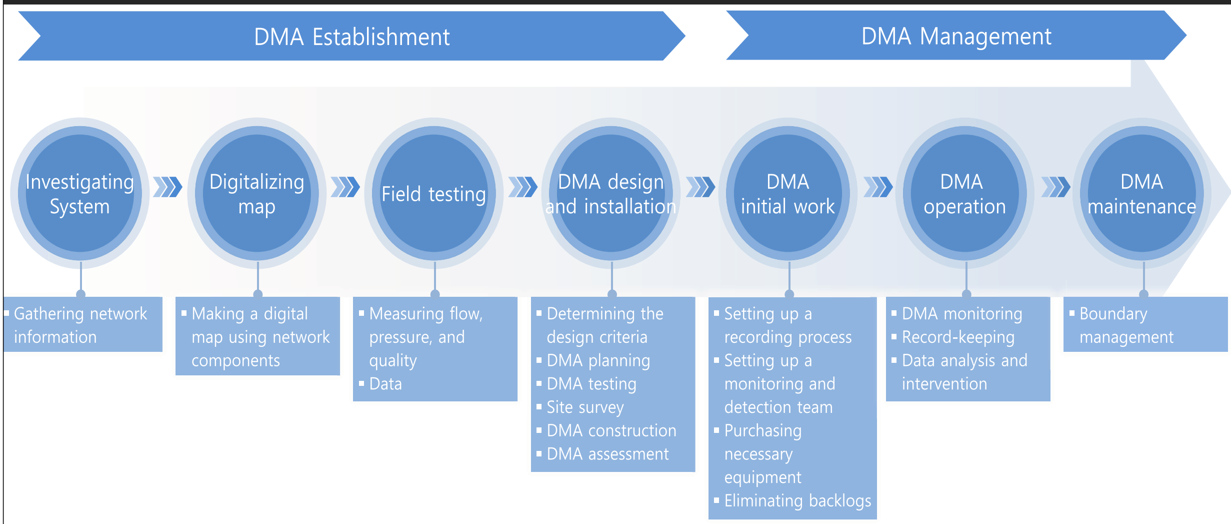
3.6 Intervention Phase: Apparent Loss Management

- **Apparent loss management program: The following figure identifies a sequence of steps for developing and implementing the apparent loss control program after the compilation of the initial top-down water audit**
  - After quantifying apparent loss, the management of data handling error, unauthorized consumption, and meter inaccuracies is implemented one by one



3.6 Intervention Phase: DMA Establishment and Management

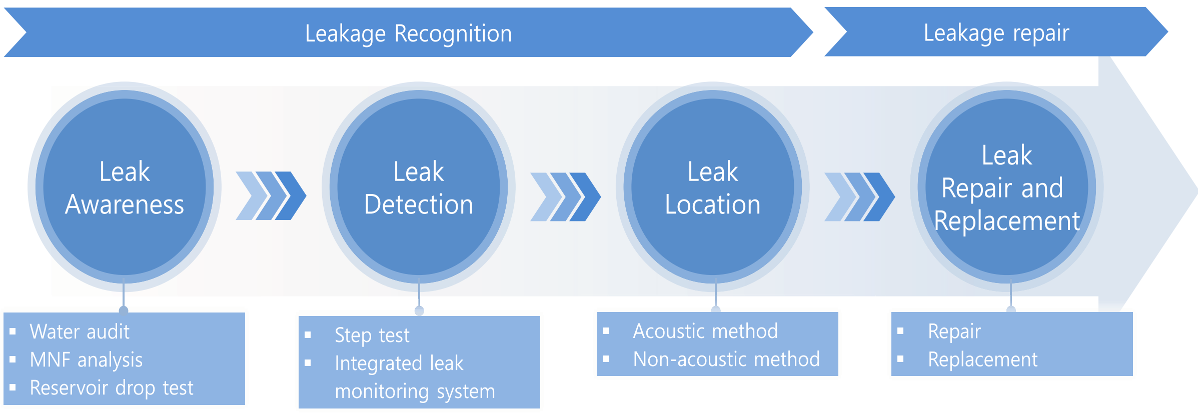
- **The process can be classified into two categories, namely, DMA establishment and management**
  - DMA establishment: DMA is designed using the plans of the distribution network and applying local knowledge of the supply system
  - DMA management: After setting up the DMA, proper initial, operation, and maintenance work should be performed to prevent DMA demolition in a few years



[Process of DMA Establishment and Management]

3.6 Intervention Phase: Leak Detection, Location, and Repair

- **Procedure: Leakage amounts in the water network can be reduced through leakage recognition and repair**
  - The procedure of leakage recognition is composed of three main steps, namely, leak awareness, detection, and location



[Process of Leakage Recognition and Repair]

3.6 Intervention Phase: Pressure Management

- **Methods: To manage pressure in PMZ, several methods can be implemented**

01 CREATING A PRESSURE MANAGEMENT ZONE

Creating a pressure management zone is more important than any pressure controller

02 REDUCING PUMP HEAD

This method is applicable if the reduced level of pumping can maintain the required minimum pressure

03 VARIABLE SPEED PUMP CONTROL

In networks with direct pump infeed, variable speed pumps with intelligent control systems can be used to reduce excessive pressures during off-peak periods of the day

04 BREAK PRESSURE TANKS

Traditionally, water utilities will construct break pressure tanks and effective small service reservoirs to reduce pressure

05 PRESSURE-REDUCING VALVE

The modern equivalent of break pressure tank is the pressure-reducing valve (PRV)

[Pressure Management Methods]

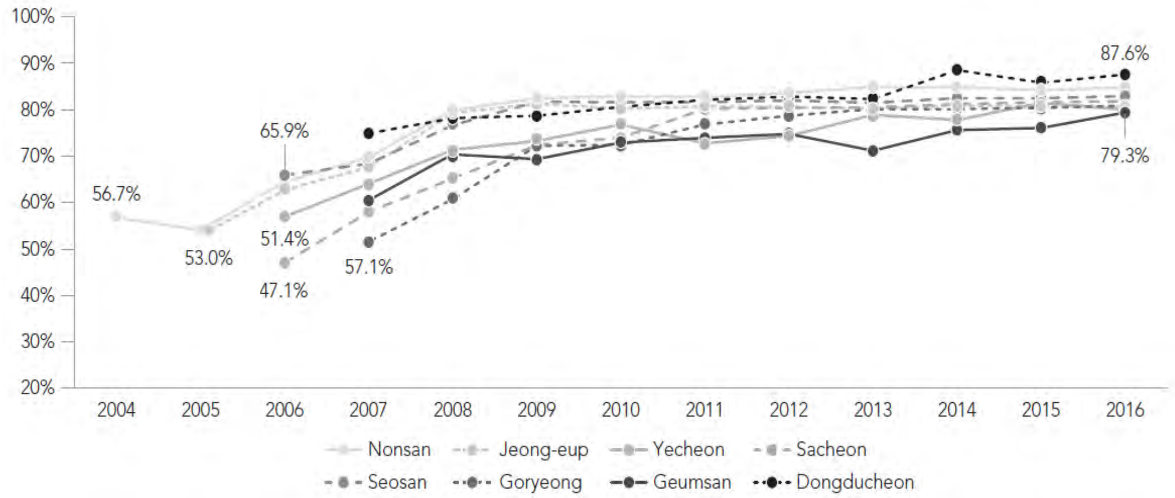
3.7 Evaluation Phase

- **(Objects) The main objects of evaluation phase are assessing the success of the intervention actions and this evaluation must be carried out on a monthly basis during water loss control porgram**

[The Evaluation Phase in Water Loss Control Program]

3.7 Evaluation Phase: Performance Assessment & Benchmarking

- **Using performance indicators: Benchmarking with PIs is a simple and effective evaluation method**
- **Several PIs should be considered in the evaluation phase**

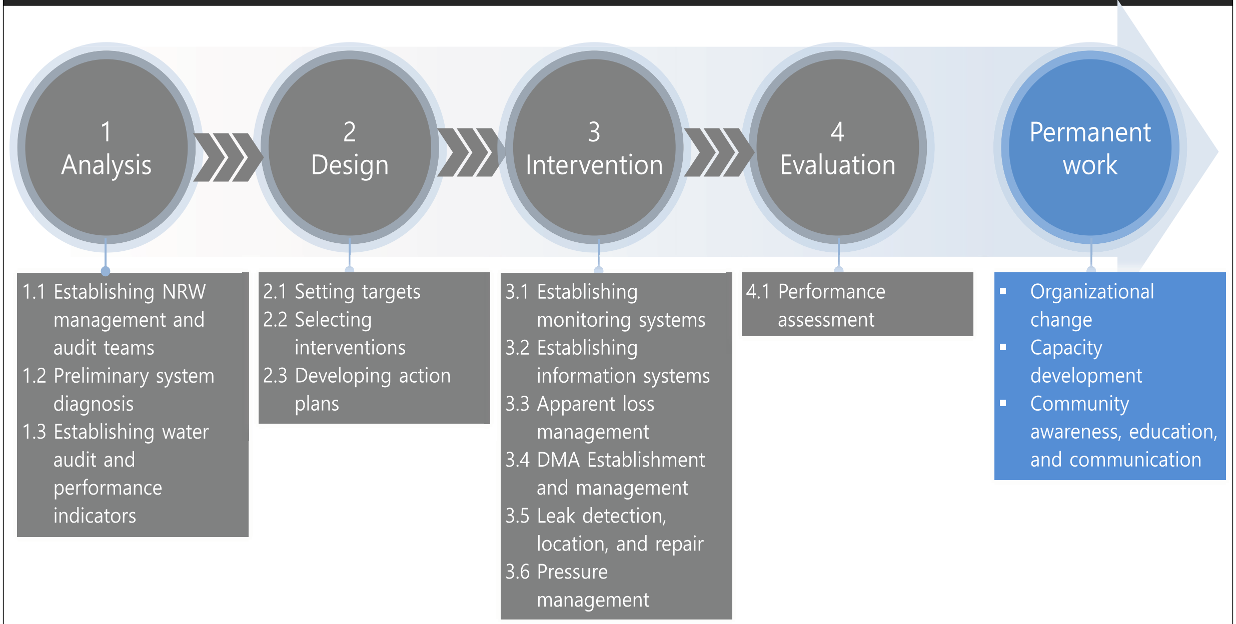


[Revenue Water Ratio of Eight Local Water Systems in Korea]

Reference : Kim (2018)

3.8 Permanent Work

- **Objectives: For successful programs and sustainable performance, permanent works should include organizational change, capacity development, and increased community relationship**



[Permanent Works in the Water Loss Control Program]

3.8 Permanent Work: Organizational Changes

- Required organizational changes: Effectively addressing NRW requires a combined effort from the management and staff throughout the utility
- Divided structure: One of the most serious problems faced by many water utilities in developing countries with regard to water loss control is the divide between the technical and financial departments within the utility
- Best practice: Indeed, the fact that when utilities change from a relatively passive attitude toward the problem of water loss to a proactive approach in conjunction with the emergence of positive results from the new strategy tends to promote an increase in motivation that initially gives rise to a new dynamism across the utility structure

3.8 Permanent Work: Capacity Development

- Importance: NRW reduction is not only a technical issue. Implementing a successful NRW program and achieving strong results require committed management and trained staff that continuously work to retain low levels of NRW
  - To adapt and reap the full benefits from an NRW management system, the water utility must implement a comprehensive training and technology transfer program to secure continued positive results
- Definition: Capacity development is the process of strengthening the abilities of individuals, organizations, companies, and societies to effectively and efficiently utilize resources and realize goals on a sustainable basis
- Agreement: Trainers and trainees should reach a consensus on a carefully designed strategy for capacity development, which includes a comprehensive training concept, because conditions vary across countries

3.8 Permanent Work: Community Awareness, Education, and Communication

- **Importance: Water loss is not only an engineering problem but also a reflection of the sociocultural situation that requires changes in community behavior and attitude toward water usage.**
  - For many years, community awareness and education have been considered the ugly, useless step-child of water demand management.

- **Critical factor to success: Frequently, well-designed and implemented technical interventions fail miserably because the community being served is excluded from the overall process. As a result, the community does not *buy-into* the project.**

- **Difficulty in monitoring: Unfortunately, activities geared toward community awareness and education are difficult to monitor with regard to cost compared to savings achieved. Both aspects are impossible to quantify.**

4. Example #1: Implementing SWM Instrument and Solution for Water Loss Management

4.1 Implemented SWM Instrument and Solutions
4.2 Analysis
4.3 Intervention
4.4 Permanent Work

4.1 Implemented SWM Instrument and Solutions

- **(Implementing SWM technologies) Water utilities can select appropriate SWM instruments and solutions to improve traditional water loss management**

Traditional Water loss management Phase	 Activities	Implemented SWM Instrument and Solutions
Analysis	Establishing NRW management and audit teams	
	Preliminary system diagnosis	
	Establishing water audit and performance indicators	- Minimum night flow analysis using - Comparative analysis - Near real-time water audit
Design	Setting targets	
	Selecting interventions	
	Developing action plans	

3.2 Integrating Traditional Methods with SWM

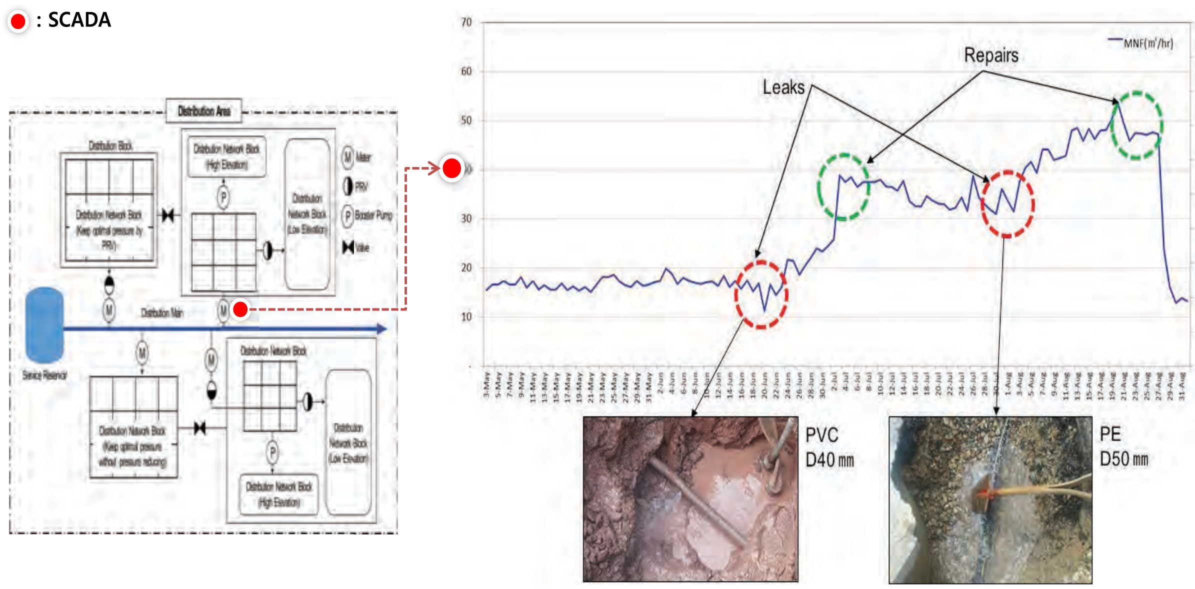
Traditional Water loss management Phase	 Activities	Implemented SWM Instrument and Solutions
Intervention	Establishing monitoring systems	- Monitoring system establishment
	Establishing information systems	- Information system establishment
	Apparent loss management	- Customer usage analysis - Changing manual meter reading to automatic meter reading
	DMA establishment and management	- Map digitalization and updating - Virtual DMA
	Leak detection, location, and repair	- Sub-divisions of DMAs - Automated step test - Integrated leak monitoring system - Leakage event detection system - Leak location equipment - In-house(after meter) leak detection and warning
	Pressure management	- Flow-modulated and remote-controlled pressure control using PRV

4.1 Integrating Traditional Methods with SWM

Traditional Water loss management		Implemented SWM Instrument and Solutions
Phase	Activities	
Evaluation	Performance assessment	
Permanent work	Organizational change	
	Capacity development	
	Community awareness, education, and communication	- Real-time water consumption information sharing

4.2 Analysis: Minimum Night Flow Analysis

- (MNF analysis) A gradual increase in minimum hour flows over periods of days or weeks is a good indication that new leaks have developed in DMA

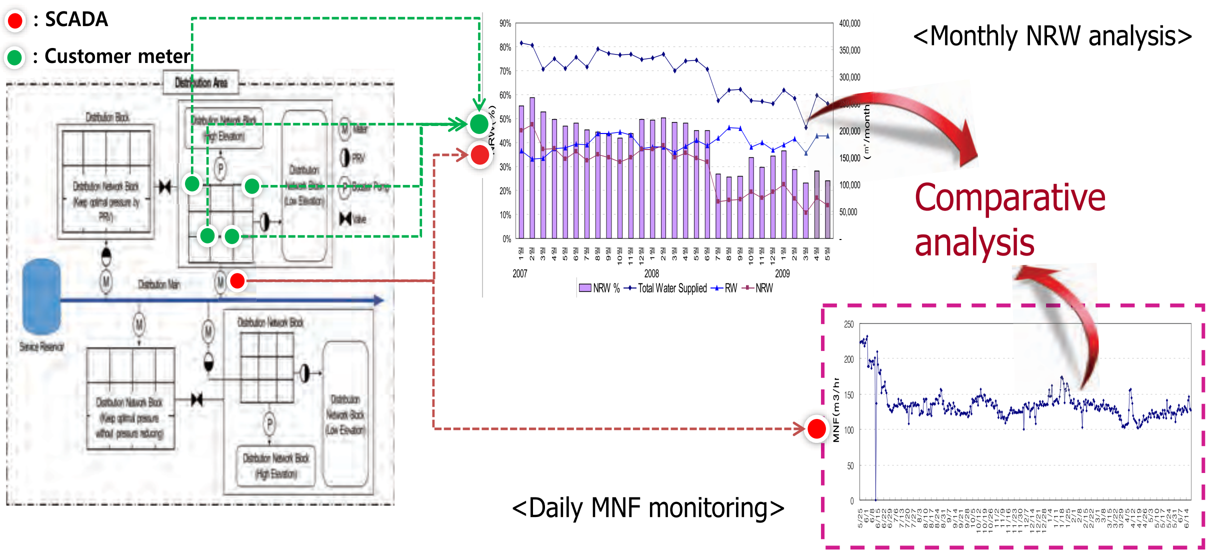


[Minimum Night Flow Analysis from SCADA Data]

Source: K-water

4.2 Analysis: Comparative Analysis

- **Comparative analysis: Utility managers must, therefore, verify the result using component analysis (top-down approach) or physical loss assessment (bottom-up approach)**

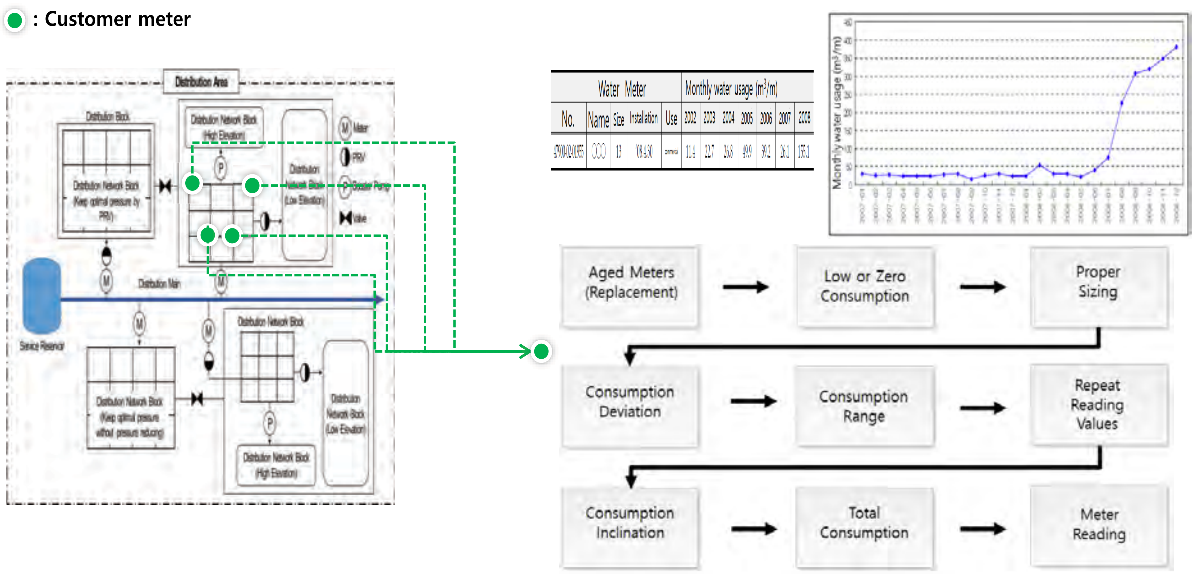


[Comparative Analysis from SCADA Data and Customer Meter (Manual or Automatic) Data]

Source: K-water

4.3 Intervention: Customer Monthly Usage Analysis

- **(Identifying issues for each customer) Prior to the on-site survey, the standardized customer monthly usage analysis should be used to identify the problems of each customer**



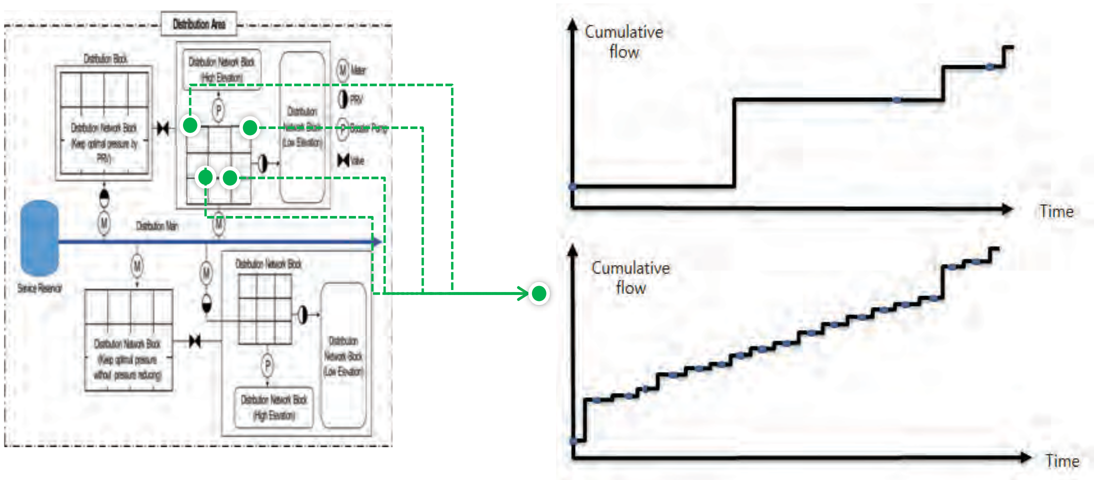
[Customer Monthly Usage Analysis from Customer Meter (Manual or Automatic) Data]

Source: K-water

4.3 Intervention: Changing MMR to AMR

- (AMR) Smart metering eliminates the need for meter readers and will eliminate many inaccuracies in metering and billing through the use of electronic meters and/or meter reading devices

●: Customer meter

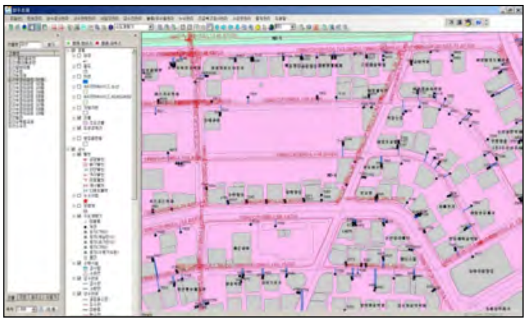


[Changing Manual Meter Reading to Automated Meter Reading]

4.3 Intervention: Map Digitalization and Updating

- (Map digitalization) Based on the collected data, a digitalized map should be made in the form of CAD or GIS
- (Updating) Data on network components and operation and maintenance should be regularly updated

(a) Digitized Map (CAD, General Version)



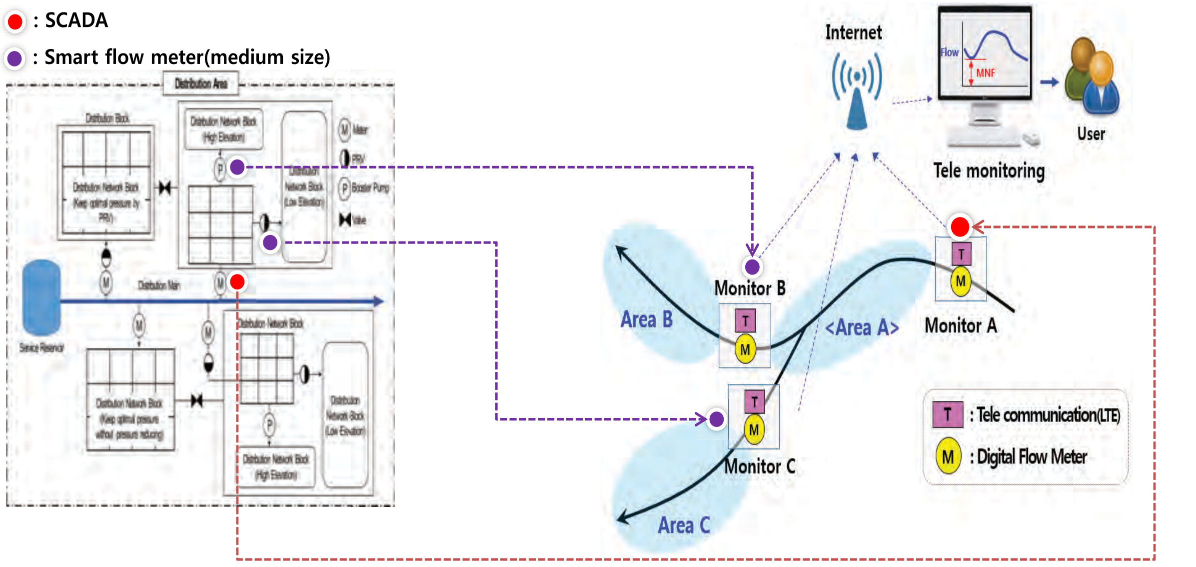
(b) Digitized Map (GIS)

[Example of Map Digitalization]

Source: K-water

4.3 Intervention: Sub-division of DMAs

- **Sub-division: Large-sized DMAs or zones can be sub-divided through internal valving or metering to detect leakage**

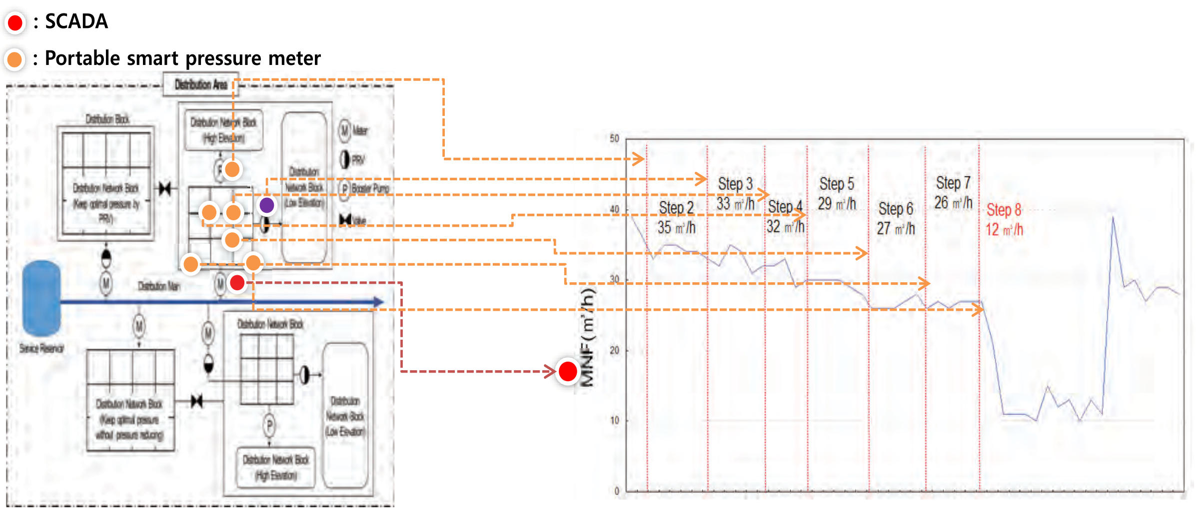


[DMA Sub-division by Metering]

Source: K-water

4.3 Intervention: Automated Step Test

- **(Automated step test) Step testing should be conducted at night when demand is at the minimum level, and customers should be notified beforehand that the supply will be disrupted**



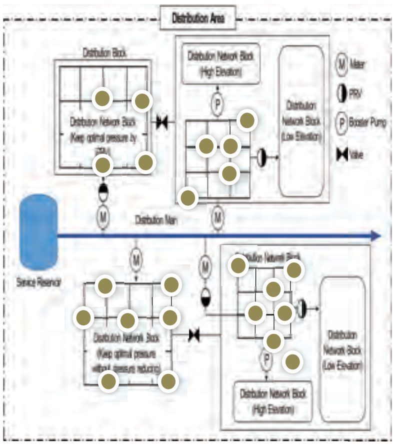
[DMA Sub-division by Metering]

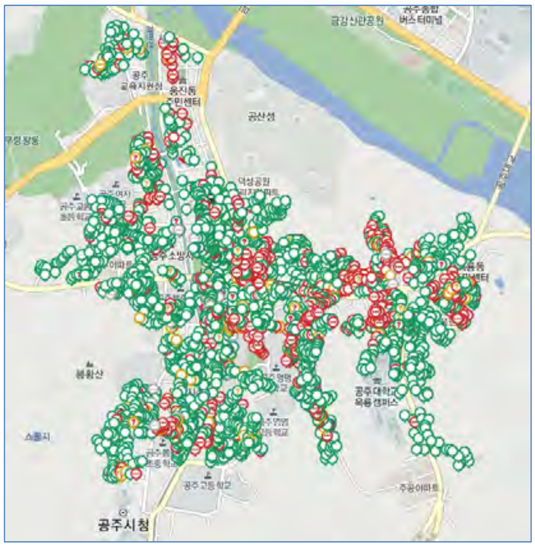
Source: K-water

4.3 Intervention: Integrated Leak Monitoring System

- (Integrated leak monitoring system) Leak noise monitoring system aims for automatic monitoring and data collection with cost-effective, wireless, and movable noise loggers

● : Leak noise logger





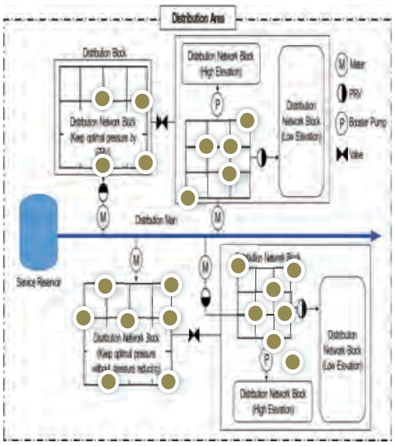
[~~~~]

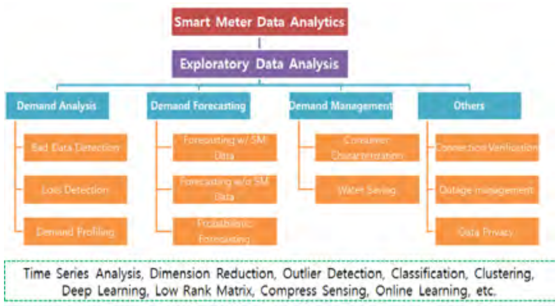
Source: K-water & USOL

4.3 Intervention: In-Property Leak Detection and Warning

- (In-property warning) Using near real-time water consumption data, water utilities can provide in-property leak warning to customers

● : Leak noise logger



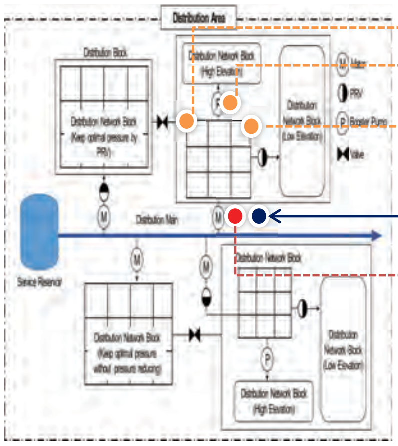


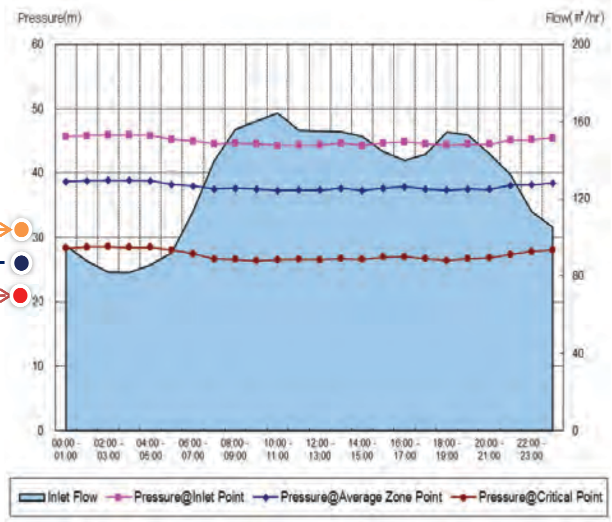
[In-house Leak Detection using Smart Meter]

Source: K-water

4.3 Intervention: Pressure control

- **(Flow-modulated and remote-controlled pressure control) Different outlet pressures can be set for different flow rates to maintain the minimum required pressure in the zone during peak flow or the PRV's outlet pressure is adjusted via pressure sensors at critical points**





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Source: K-water

Thank you very much