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SYSTEMS REFERENCE DELIVERABLE

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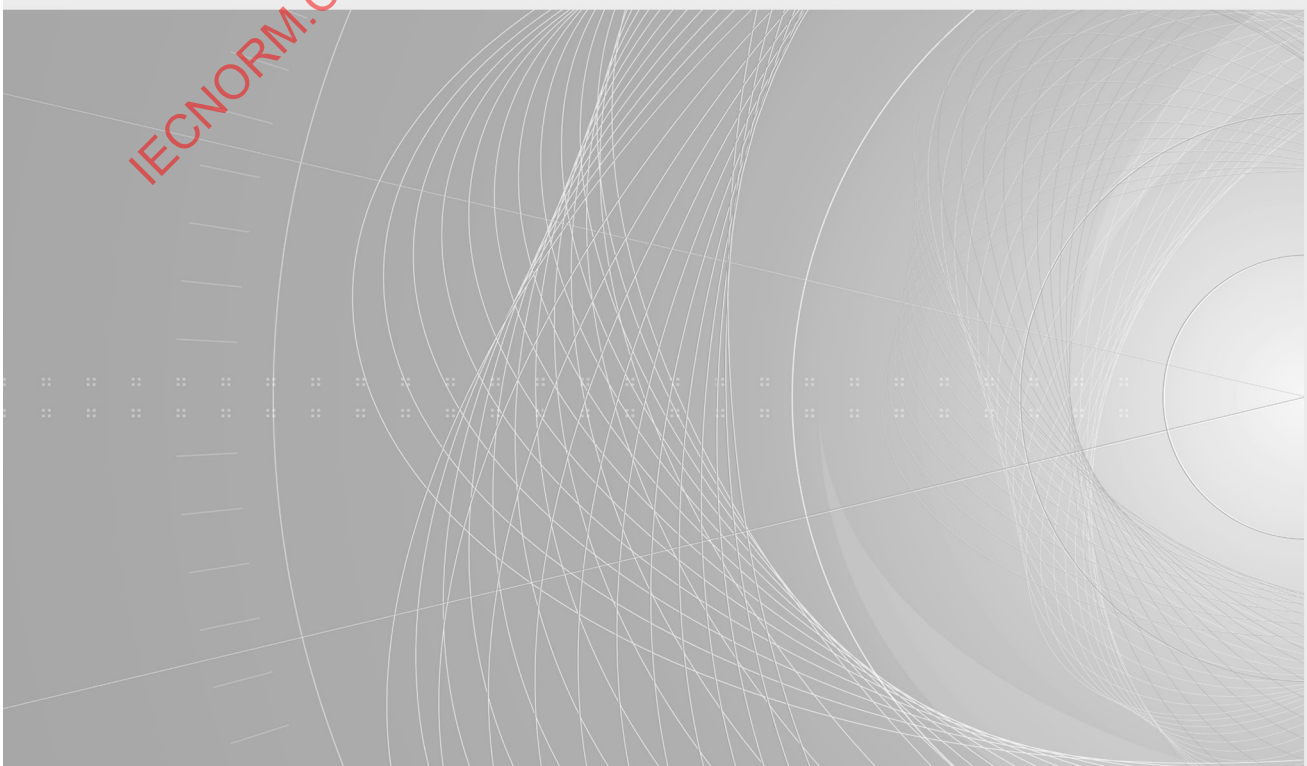
Smart city use case collection and analysis – Water systems in smart cities – Part 1: High-level analysis



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Smart city use case collection and analysis – Water systems in smart cities – Part 1: High-level analysis

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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SMART CITY USE CASE COLLECTION AND ANALYSIS – WATER SYSTEMS IN SMART CITIES –

Part 1: High-level analysis

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The text of this Systems Reference Deliverable is based on the following documents:

Draft	Report on voting
SyCSmartCities/351/DTS	SyCSmartCities/359/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Systems Reference Deliverable is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 63301 series, published under the general title *Smart city use case collection and analysis – Water systems in smart cities*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

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INTRODUCTION

The construction of a smart city can create benefits for a society and its stakeholders. Water is a critical resource to support urban development and its sustainable use is recognized as a UN Sustainable Development Goal. Water infrastructure development, water management efficiency, water supply resilience, and the safe operation and use of water are important focal areas for IEC SyC Smart Cities.

This document focuses on water systems management, specifically water security whether directly from a natural source or via man-made infrastructure. Information and communications technologies (ICT) and electro-technologies can provide greater visibility and control, however their application does depend on the characteristics of individual water markets. Technology is not a panacea for resolving all issues and problems.

A gap exists in effective coordination and clear orientation and how industry and stakeholders are engaged within it.

Major stakeholders of water management and use include citizens, the water authority (government), and organizations (associations, business groups, utility companies). Each stakeholder has different and competing interests, market relationships and touch points to water system infrastructure, processes, operations, management and use.

Modelling these complex interactions into a systems architecture is a valuable exercise in understanding the issues, gaps and opportunities for sustainable water management.

This document focuses on use case collection and analysis to elicit requirements to support technical committees such as ISO/TC 224 and ISO/TC 147 in preparing sustainable water management standards for cities and communities.

This document also seeks to inform IEC technical committees to enable them to provide the technical standards needed.

SMART CITY USE CASE COLLECTION AND ANALYSIS – WATER SYSTEMS IN SMART CITIES –

Part 1: High-level analysis

1 Scope

This part of IEC 63301 provides an overview of water systems in smart cities, establishes a general approach for use case collection and analysis, and identifies major stakeholders and application areas for high-level analysis of water systems.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
water system
open system that manages the capture, cleanliness, flow, storage, consumption, re-use and disposal of water resources

Note 1 to entry: A water system covers water environment, water supply, water consumption, water draining and water recycling, representing a multi-dimensional open system engaging nature, human behaviour, and socio-economics.

Note 2 to entry: A city is only directly responsible for part of a water system, and coordinates with other agencies working on the water environment.

3.2
smart water system
water system that uses information and communications technology to monitor and automate operations, deliver supply in response to demand and manage its re-use and disposal in efficient ways

Note 1 to entry: The data collection through the sensors allows near real-time management of a water service system.

Note 2 to entry: Data analytics support planning, predicting, accurate management and intelligent control and appropriate decision-making of a water service system.

Note 3 to entry: A smart water system supports safe and effective operation of a water system under all conditions.

3.3
use case
specification of a set of actions performed by a system, which yields an observable result that is, typically, of value for one or more actors or other stakeholders of the system

[SOURCE: ISO/IEC 19505-2:2012, 16.3.6]

3.4
use case template
form which allows the structured description of a use case in predefined fields

[SOURCE: SG-CG/M490/E:2012-11, 3.2]

3.5
actor
entity that communicates and interacts

[SOURCE: IEC 62559-2:2015, 3.2, modified – Note 1 to entry has been deleted.]

3.6
grouping
group of actors in order to organize an actor list

3.7
stakeholder
individual, group or organization that has an interest in an organization or activity

Note 1 to entry: Usually a stakeholder can affect or is affected by the organization or the activity.

3.8
scenario
possible sequence of interactions

[SOURCE: SG-CG/M490/E: 2012-11, 3.10]

3.9
business case
use case which provides justification for undertaking a project, programme or portfolio, through evaluating the benefit, cost and risk of alternative options

3.10
high-level use case
HLUC
use case which describes a general requirement, idea or concept independently from a specific technical realization like an architectural solution

[SOURCE: SG-CG/M490/E: 2012-11, 3.4]

4 An overview of water system

4.1 Basic mechanism

4.1.1 Coupling characteristic

The water system is an open systematic compound characterized by coupling between natural water system and economic and social (human) activities, as shown by Figure 1.

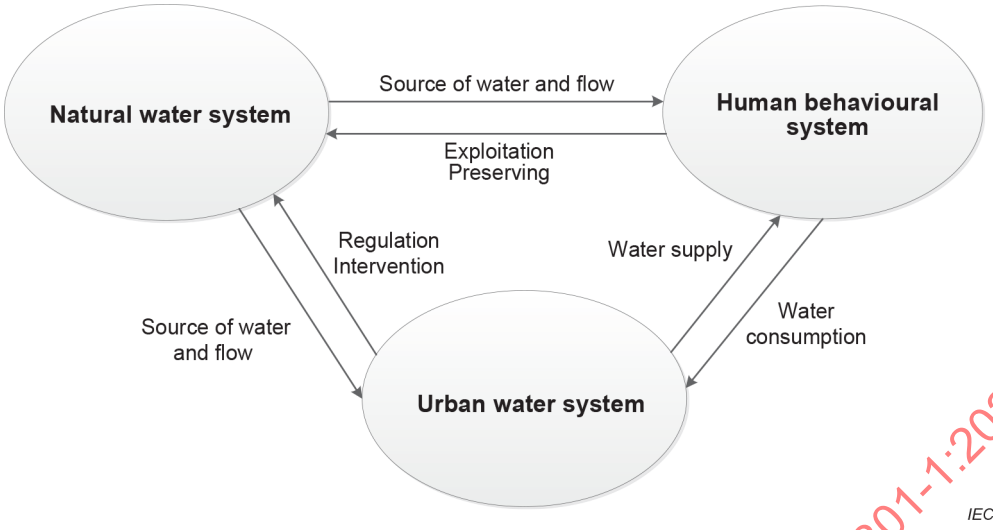


Figure 1 – Coupling characteristic of water system

Natural water system supplies water resources and water environments for human, animal and plant consumption, while also placing constraints on human behaviours as a result of flooding, drought, and soil erosion. Careful proactive management of water is important to sustain natural water resources use. This requires a combination of modern infrastructure and environmental preservation to supply resources to urban communities, protect the natural environment through effective and timely regulation and intervention, which is the very essence of the urban water system.

Such a trilateral coupling characteristic of the water system constitutes the very basics for the analysis of any water-related activities.

4.1.2 Integrality

According to Von Bertalanffy's General System Theory, the system as a whole is more than the sum of individual constituting parts, and the integral function of the system prevails over the aggregation of sectoral functions. When it comes to water system, it is important that a mentality of integrality is upheld, with the operation of water environment, water source, water consumption, water draining, and water recycling organized holistically, emphasizing general performance and effectiveness of the water system.

In short, the smooth and optimized operation of the water system relies on coordinated and efficient operation of each block joined together as a whole.

4.1.3 Dynamism

The operation of water system is closely linked to local ecological, economic, and social conditions, as determined by the basic coupling characteristic. The study of water system is therefore set on a dynamic course of evolution, affected by contemporary technological, socio-economic backgrounds.

For this document, the study of water system is carried out against the backdrop of smart city, so that fundamental ideology and concepts of smart city are brought into deliberation in this document.

4.2 The ecosystem

For the water system, the conducting of human activities cannot be segregated from the status of natural water system, in other words, the operating of water system follows the natural laws for raw water as well as socio-economic rules for water utilization.

The major constituting blocks and interactions within water system are demonstrated in Figure 2, ranging from natural water resources to social and economic factors related to water.

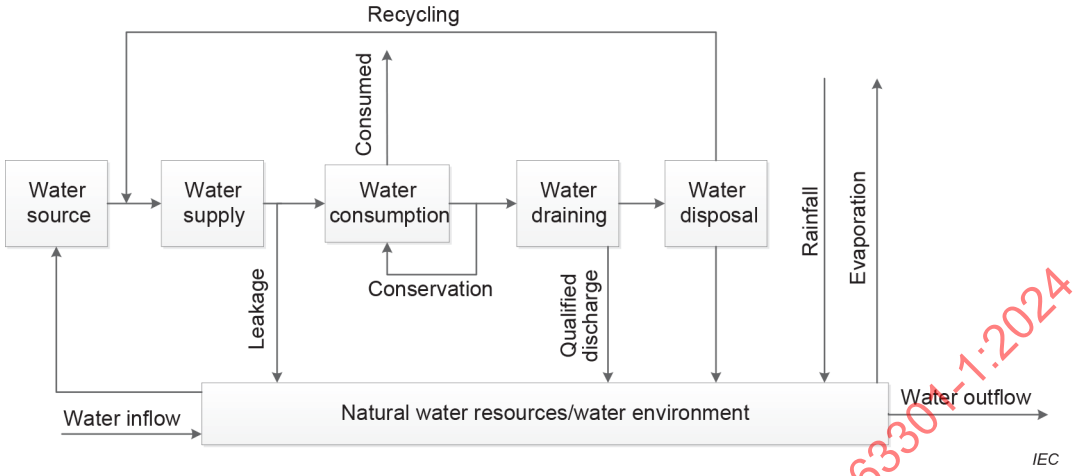


Figure 2 – A simple anatomy of water system

From the perspective of participating actors, the anatomy of water system given by Figure 2 can be further enriched to engage several groups of actors (groupings), as given by Figure 3.

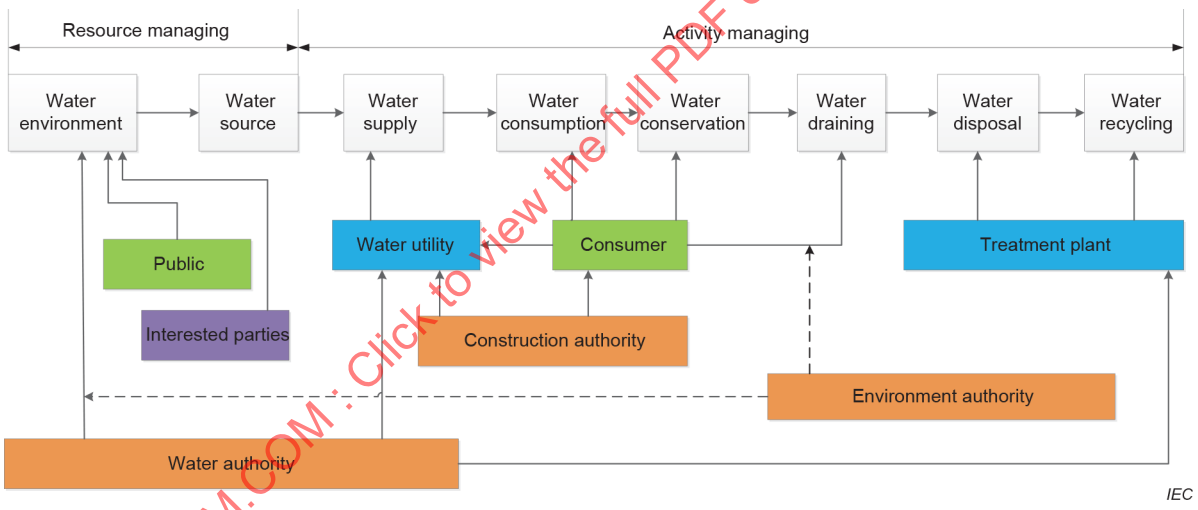


Figure 3 – Stakeholders within water system

As depicted by Figure 3, generally four groups of stakeholders can be identified for water systems:

- Authority: in charge of general water management.
- Public and consumer: directly engaged in water consumption, water conservation, water draining, and takes a big interest in environmental issues.
- Water utility and water treatment: accountable for important processes of water supply, water disposal, and water recycling.
- Interested parties: economic and social entities whose operational activities have an impact on the water environment, for instance, agriculture, mining, construction, manufacturing, energy supply, recreation.

See Annex A for a full list of stakeholders.

5 Approach for use case collection and analysis

5.1 General

A top-down approach is adopted in the process of use case collection and analysis described in this document, following the general methodology specified by the IEC 62559 series. See Figure 4.

At the beginning of use case collection and analysis, a general study of water system is needed, the purposes of the work of system study include identifying sub-systems, identifying basic stakeholder needs, and forming materials for sub-system analysis as use case prototypes.

Use case building starts from breaking down stakeholder needs and developing use cases using the templates.

Use cases can be arranged in database, based on which a set of common requirements can be identified for water system so as to scope out a family of standards.

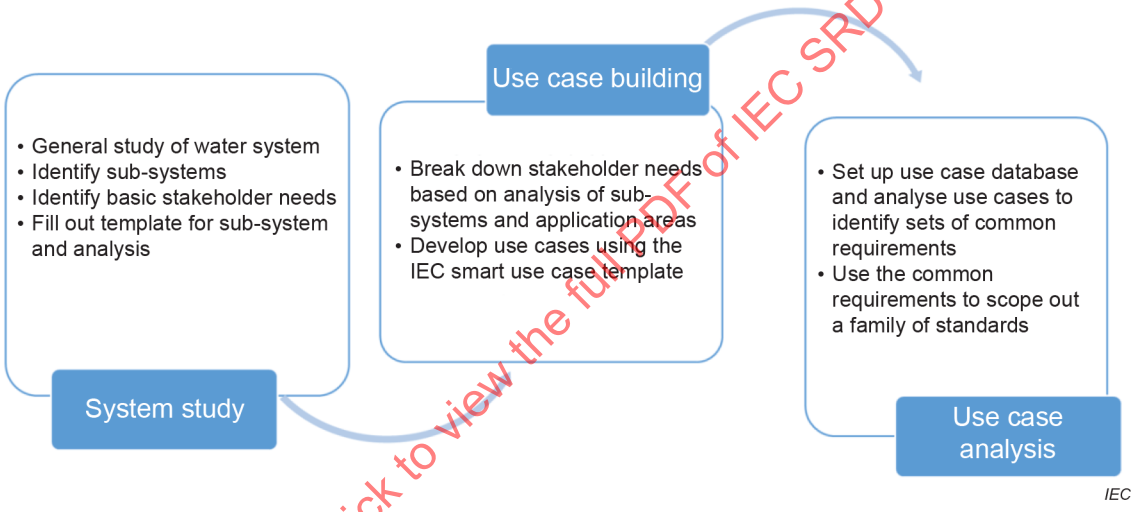


Figure 4 – Approach for use case collection and analysis

5.2 User stories

User stories are based on an initial stakeholder statement of need and corresponding actions and outcome under certain circumstances. An example sentence is as follows:

"As a municipal government officer, when I am monitoring the water supply and water intake in the city, I need to collect water storage reservoir and water inlet water quantity, water quality monitoring data, thus I can have a comprehensive and intuitive grasp of the city's water resources."

The key words are "As a" (Title), "when I am" (Situation), "I need to" (Motivation), "so that" (Outcome).

6 Use case template consideration

6.1 Template for high-level use cases

High-level use cases are provided in the following format, see Table 1.

Table 1 – Template for high-level use cases

Need statements	Description of the general need leading to the HLUC
Objectives	Focus areas and goals that are essential to the HLUC
Current practice	Current practice in use of people, process, technology, data, policy to achieve the objective
	Rationale for the use case and alignment to related UN SDG6 indicator(s). See Annex C for information.
Gaps	Gaps to be addressed for the HLUC
Stakeholders	Stakeholder roles and responsibilities
Relationship between the stakeholders	Interacting patterns between the stakeholders that are of importance for analysis of the HLUC
Scenarios	Contextual illustration in relation to the HLUC
Requirements	Specific requirements to be addressed

6.2 Template for user stories

The key words for user story template are "As a" (Title), "when I am" (Situation), "I want to" (Motivation), "so that" (Outcome), see Table 2.

Table 2 – Template for user stories

No.	Type of stakeholders	Motivation	Situation	Expected outcomes	User story description
1					

6.3 Use case template

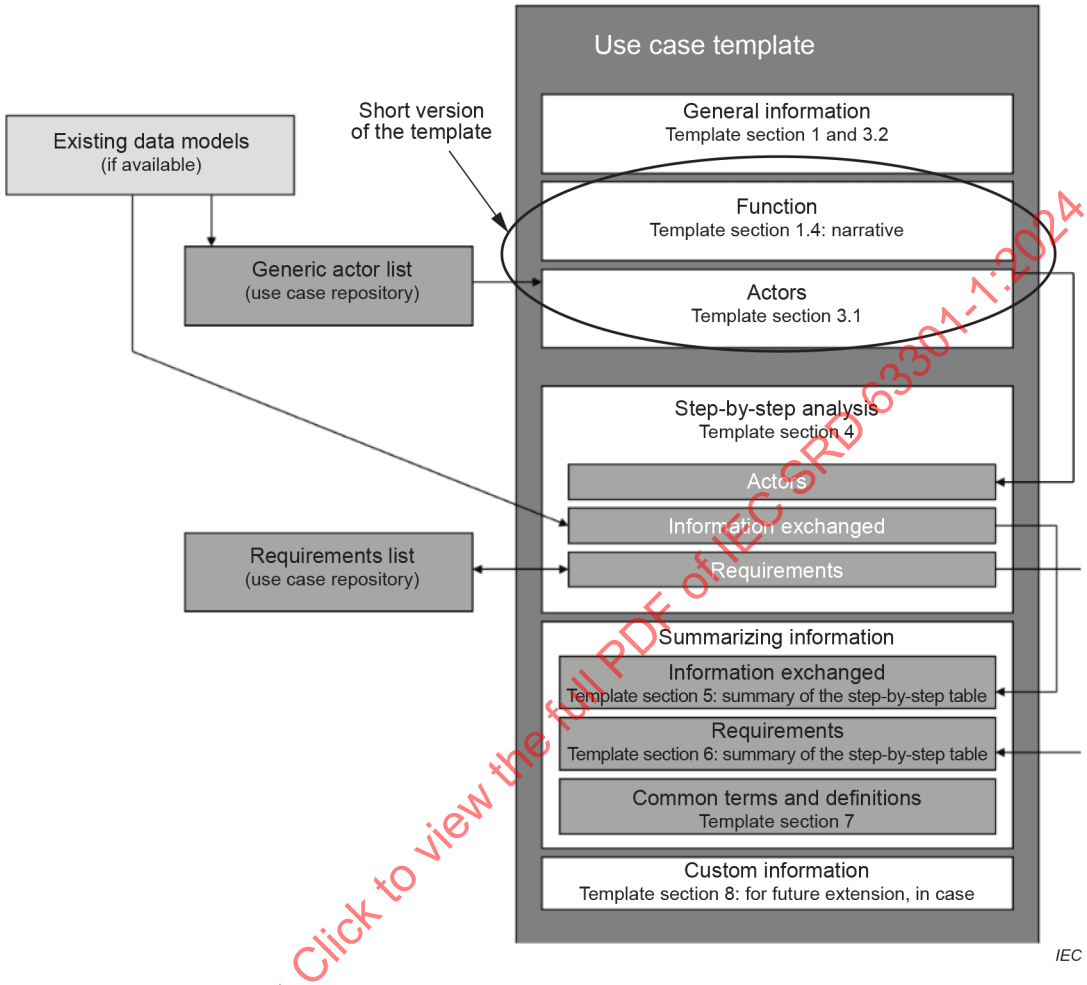
The use cases to be collected and analysed in this document are to be arranged using the template provided by IEC 62559-2:2015, which gives a framework for a formal description of particular use cases and is currently broadly accepted in the international community of standardization, supported by plenty of useful tools, such as Use Case Management Repository (UCMR) that has been used for common development and information sharing during the work conducted in the context of the European Standardization Mandate M/490.

The structure of the IEC 62559-2 template is shown in Figure 5, which also provides an overview of internal relations and the relation to actor list and the requirements list.

Because the IEC 62559-2 template is exhaustive, it can be argued that the description of particular use cases is comparatively time consuming. To address this concern, the template offers a short version; in accordance with IEC 62559-2, only the following fields are mandatory covering the minimum short version of a use case which is mainly used for a first version of a new use case:

– name of use case;
– author;
– date;
– narrative;
– actors.

The short version is the basis for the complete use case and can simply be extended with the addition of further information, i.e. without rewriting the use case. Being self-explanatory, the short version is seen as an easy starting point for domain experts without going into every detail of the use case methodology and its complete use case template.



SOURCE: IEC 62559-2:2015, Figure 2.

Figure 5 – Overview of the use case template

Another point is that the IEC 62559-2 template is generally rooted in the study of smart grid; to improve applicability of the template and achieve coordinated progress of use case collection, IEC SyC Smart Cities is deliberating on pushing forward a new project on use case template and methodology that is suitable for smart cities.

This document adopts the IEC 62559-2 template. Some of the key use cases are produced using the full version template, as demonstrated by Annex B. Other use cases are arranged using the short version.

7 Application areas

7.1 General

Based on the lifecycle of water systems, a range of application areas (or sub-systems) can be identified. Specifically, this document deals with the following application areas.

– Application area 1: Water resource protection and preservation
– Application area 2: Robust water supply
– Application area 3: Smart water drainage system
– Application area 4: Resilience-based flood management and prevention
– Application area 5: Flood management and prevention
– Application area 6: Flood control and relief
– Application area 7: Intelligent manhole cover monitoring system
– Application area 8: Water data platform and cyber physical systems

Each application area may cover a set of HLUCs that share common concerns and features.

7.2 Structure for application area

Each of the above application area descriptions adheres to the following structure.

a) Need statements: Describing the problems and conditions for water systems that need to be solved or addressed.
b) Objectives: Describing the aims or goals of applying water system solutions in the specific area.
c) Current practices: Describing the existing exercises or operations in the specific application area.
d) Gaps: Indicating the differences, especially undesirable ones, between needs statements and the current practice.
e) Stakeholders: A person or group of people with an interest or concern in the specific application areas.
f) Relationship between the stakeholders: Describe the way in which two or more stakeholders interact with regard to water system.
g) Scenarios: the contextual illustration for specific application area.
h) Requirements: The requirement can be the function, user, data, laws and regulation, standards, life cycle consideration and others relevant to the application area.

When describing stakeholders for the specific application area of water systems, the following roles are used:

– Primary beneficiary: stakeholder who benefits directly from the solution.
– Secondary beneficiary: stakeholder who benefits indirectly from the solution.
– Tertiary beneficiary: stakeholder who benefits indirectly from the solution at one further step removed.
– Owner: stakeholder who owns or manages the solution.
– Designer: stakeholder who can participate in designing the solution.
– Builder: stakeholder who can participate in building the solution.
– Maintainer: stakeholder who can participate in maintaining the solution.
– User: stakeholder who uses the solution to help meet their needs.

7.3 Water resource protection and preservation

7.3.1 Need statements

To rationally explore, use, preserve and protect water resources, prevent and control water hazards, realize the sustainable use of water resources, in pace with economic and social development.

7.3.2 Objectives

The major objectives for smart water solution regarding water resource protection and preservation include the following.

- Establish an infrastructure framework that tracks the conditions of natural water bodies covering rivers, reservoirs, lakes, among others, and supports corresponding actions.
- Guarantee the quality and supply of water to the urban supply network, minimizing water loss.

7.3.3 Current practices

Water is critical for human life and urban development; however, problems like pollution, shortage and imbalance have troubled cities globally, especially cities in the developing world, which include:

a) unclear responsibilities and accountabilities – multiple governing bodies and agencies for water pollution control without clear demarcations of responsibilities and effective structures for cooperation, worsened by reliance on limited information sharing and transparency;

b) lack of timely information about water conditions (poor water quality, water leaks, etc.) to support supply and demand;

c) lack of societal participation and engagement with citizens and communities.

7.3.4 Gaps

Access to clean water is a big concern for smart city construction. The predicament of water preservation against the backdrop of quick urbanization shall be tackled with a new mind-set, with the smart technologies applied with clear orientation building on the foundation of effective use case collection and analysis.

7.3.5 Stakeholders

– Stakeholder 1: water quality monitoring officer
  - Description: responsible for monitoring water quality, volume, surface cleanliness and related activities (mining, fishing, etc.) of water bodies such as rivers and lakes
  - Role: Primary beneficiary or designer or user
– Stakeholder 2: Sewage outflow monitoring officer
  - Description: responsible for continuously monitoring sewage quality, volume and ingredients of sewerage outflow, taking appropriate actions should there be a pollution incident
  - Role: Secondary beneficiary or designer or user
– Stakeholder 3: Comprehensive management officer
  - Description: responsible for monitoring and managing the comprehensive status of water bodies such as rivers and lakes, carrying out daily inspections and cleaning
  - Role: Primary beneficiary or designer or user

– Stakeholder 4: Officer for emergency handling
  - Description: responsible for promptly notifying and coordinating the relevant departments to deal with the reported emergency incidents, and give feedback on the results of the disposal, in case of emergency incidents
  - Role: Secondary beneficiary or designer or user
– Stakeholder 5: Sewage discharge company manager for external affairs
  - Description: responsible for keeping the governmental water department updated on the quality of sewerage discharge
  - Role: Primary beneficiary
– Stakeholder 6: Sewage discharge company manager for internal affairs
  - Description: responsible for managing sewage discharge to assure conformity to standards and regulations
  - Role: Person who manages sewage discharges
– Stakeholder 7: citizens
  - Description: responsible for reporting emergency incidents, obtaining water-related information in daily life.
  - Role: Primary beneficiary or user

7.3.6 Relationship between the stakeholders

Stakeholders 1 to 4 are generally responsible for administrative management of water resources, relying on comprehensive solutions through technological application as well as smooth cooperation with stakeholders 5 to 7. All of the stakeholders take big stakes in the common task of protecting and preserving water resources for sustainable development of the society.

7.3.7 Scenarios

For the purpose of water resource protection and preservation, a mechanism called "river chief system" is of value.

The "river chief system" refers to appointing a general river chief along with multiple branch chiefs at different levels, who work collaboratively to organize, lead, and coordinate protection and preservation work. Such a system relies on an efficient working platform to foster multi-departmental linkage, strengthening communication and collaboration between environmental protection, water conservancy, agriculture and other departments.

Business companies and citizens are also called upon to take part in the process to build a comprehensive eco-system for the common task.

7.3.8 Requirements

A comprehensive set of metrics shall be applied for testing of water qualities; metrics may include:

- pH;
- oxidation-reduction potential (ORP);
- conductivity or total dissolved solids (TDS);
- turbidity;
- dissolved oxygen;
- chemical oxygen demand (COD);
- total phosphorus;
- ammonia nitrogen.

7.4 Robust water supply

7.4.1 Need statements

To enable the city to provide stable and robust water supply, with higher efficiency of water resources utilization and minimum water loss.

7.4.2 Objectives

The major objectives for smart water solution regarding robust water supply include the following.

- Collect and manage real-time monitoring data and video through IT infrastructures, in order to grasp operating condition of water supply facilities.
- Build water resource scheduling model based on the data to support the city to provide stable and clean water for the residents.

7.4.3 Current practices

With the acceleration of urbanization, the demand for urban water is increasing, and the problem of uneven distribution and shortage of water resources is becoming increasingly prominent, as demonstrated by:

– Shortage of water supply in stark contrast to large amount of pipeline leakage. Average per-capita water resource in mega cities is relatively low, while pipeline leakage in lots of cities is not up to standard.

– The shortage of water supply leads to long-distance water transfer projects such as China's South-to-North water diversion project, which alleviate the imbalance of water resource distribution in general, while also causing anthropogenic influence on natural ecology, as well as large energy consumption.

7.4.4 Gaps

It is essential that smart water supply systems integrate new technologies such as the Internet of Things, big data, and cloud computing, whereas the integration of these technologies into the existing production system and management system of water plants is not easy, troubled by problems such as the connection of management processes and the conversion of data formats.

The integration involves not only the compatibility of hardware devices, but also data interaction, system integration and other levels, which entails a lot of research and development work.

7.4.5 Stakeholders

– Stakeholder 1: Water quality management organizations
  - Description: to protect the water environment and work out water diversion plan and supervise the water transfer activity
  - Role: Primary beneficiary or designer or user
– Stakeholder 2: Municipal governments
  - Description: to protect the water reservoir, to ensure that water quality and quantity are up to standard
  - Role: Primary beneficiary or designer or user
– Stakeholder 3: Smart technology companies
  - Description: to provide the smart technology for municipal government, water quality management organizations and water service companies
  - Role: Designer or maintainer
– Stakeholder 4: Water service companies
  - Description: to supply purified water to the city
  - Role: Primary beneficiary or designer or user
– Stakeholder 5: Financing institutions and investors
  - Description: to provide financial support for water service companies and smart technology companies
  - Role: Secondary beneficiary
– Stakeholder 6: Citizens
  - Description: to get the information about water supplied through pipelines in daily life
  - Role: Primary beneficiary

7.4.6 Relationship between the stakeholders

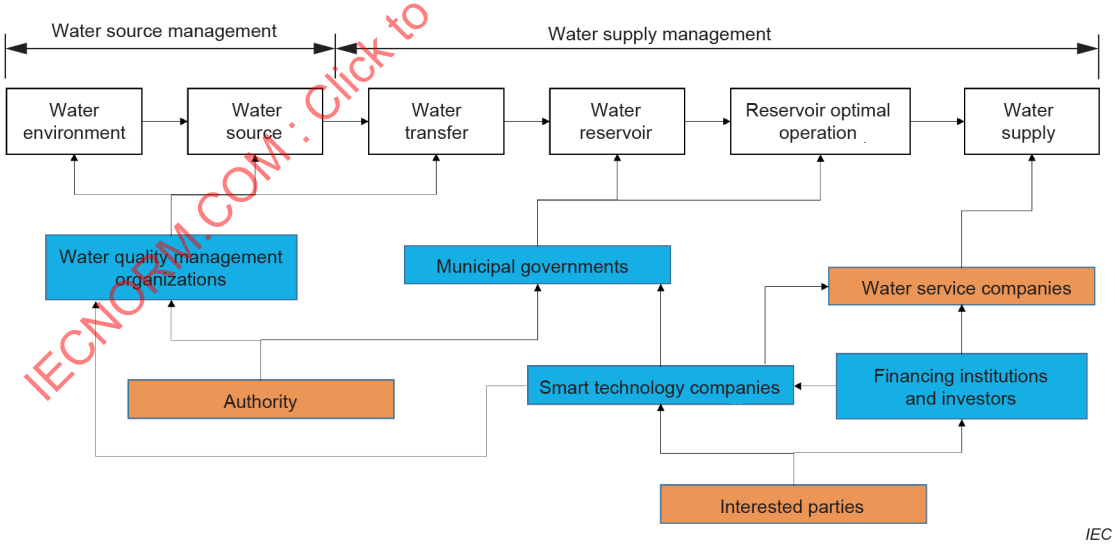


Figure 6 – Relationship between stakeholders

The water quality management organizations together with the municipal governments are responsible for making sure the water environment and water source are safe and up to standards for water supply. Water service companies are responsible for delivering water to the end users. The smart technologies provide solutions for the other major stakeholders, see Figure 6.

7.4.7 Scenarios

In Shenzhen city, China, urban growth has occurred in just 40 years with a permanent population in excess of 20 million today. Operating a reliable and resilient water supply requires 80 % of all water in that area to be diverted to the city. The implementation and use of smart technology has optimized water supply and demand management in real time. Event decision management allows for better water utilization, water discharge and pollution control in more timely and precise ways.

7.4.8 Requirements

Throughout the entire process of the water supply, the following issues shall be properly addressed:

– policy support for smart water supply;
– standard secure use of smart technology including open interoperable data transfer, processing, alerting and visualization to ensure effective water operations and management, etc.;
– long-term government backed financing policy;
– industry accredited project, programme and business management;
– public consultation and engagement;
– corporate governance standards specific to water related infrastructure, supply and disposal activities.

7.5 Smart water drainage system

7.5.1 Need statements

To develop a comprehensive solution for water drainage system to make sure the consumed water is properly dealt with and drained to enable water resource recyclability.

7.5.2 Objectives

Objectives of the smart technology investment in urban deep drainage transmission system include the following.

- Manage and control deep drainage tunnel operation data to optimize operations and maintenance workload and frequency using digital and sensor technologies to predict and proactively maintain and to react responsively in a timely manner.
- Formulate water dispatch and economic operation strategies for each pre-treatment station in the deep tunnel by capturing and comparatively analysing multi-dimensional big data.
- Securely use video surveillance and image recognition for real-time on-site remote management, with privacy controls in place.
- Model hydraulic flows to calculate and predict water supply in deep tunnels from collected data across multiple systems and silos on a regular basis.

7.5.3 Current practices

Lots of cities are facing sewage treatment problems that it is crucial to address, including:

– The sewage treatment plant is centralized.
– The "not in my backyard" phenomenon is very common.
– Sewage treatment upgrading is urgent.
– Confluence of rain and sewage causes frequent urban waterlogging.

The method of developing "deep drainage tunnel" to deal with the sewage in large amount is a way to solve the above problems. As there are no particular specifications for the operation and maintenance of the deep drainage transmission system, it results in high operating costs, high energy consumption, and high safety risks. So, it is essential to standardize the application of intelligent technology in the deep drainage transmission system.

7.5.4 Gaps

The traditional sewage treatment follows a centralized model, with each party occupied with its own assigned tasks, resulting in the so-called "not in my backyard" phenomenon, which significantly hinders the general efficiency and quality of sewage treatment in the process of smart city construction. Furthermore, the general technical systems for sewage treatment currently in use cannot meet the challenges such as confluence of rain and sewage, resulting in frequent waterlogging. An upgrading of sewage treatment in terms of technology as well as management is therefore urgently needed.

7.5.5 Stakeholders

– Stakeholder 1: SPV(Special Purpose Vehicle) company manager
  - Description: responsible for the project design, investment and financing, construction, operation and maintenance and handover
  - Role: Designer or builder or maintainer
– Stakeholder 2: Government water bureau officer
  - Description: responsible for monitoring quality and discharge volume, for protecting water resources (rivers, lakes, etc.) and for taking appropriate action to prevent pollution
  - Role: Primary beneficiary or designer or user
– Stakeholder 3: Government construction bureau officer
  - Description: responsible for guiding the city planning, managing the city's construction activities, monitoring the quality of construction projects
  - Role: Primary beneficiary or designer or user
– Stakeholder 4: Urban drainage company manager for pipe network management
  - Description: responsible for collecting the information about sewage collection and transmission capacity of the deep tunnel system, adjusting the drainage route of the surface pipe network
  - Role: Primary beneficiary or user.
– Stakeholder 5: Smart water company manager for intelligent facility
  - Description: responsible for integrating intelligent technology into drainage system (including real-time management and control, prediction and early warning system, unmanned aerial patrol management system, etc.
  - Role: Designer or builder or maintainer
– Stakeholder 6: Smart water company manager for intelligent facility development
  - Description: responsible for import and development of intelligent technology and facilities into the water drainage system in the city
  - Role: Designer or builder or maintainer
– Stakeholder 7: Financing investment manager
  - Description: responsible for providing financial support to project construction and obtaining a return
  - Role: Builder

– Stakeholder 8: Sewage treatment company quality manager
  - Description: responsible for managing sewage discharge and ensuring discharged sewage meets the requirements of standards and regulations
  - Role: Primary beneficiary or user
– Stakeholder 9: Sewage treatment company general manager
  - Description: responsible for processing daily sewage of the city and ensuring the treatment function is running well
  - Role: Primary beneficiary or user
– Stakeholder 10: citizens
  - Description: to obtain water drainage-related information, and to give suggestions to the drainage system
  - Role: Primary beneficiary or user

7.5.6 Relationship between the stakeholders

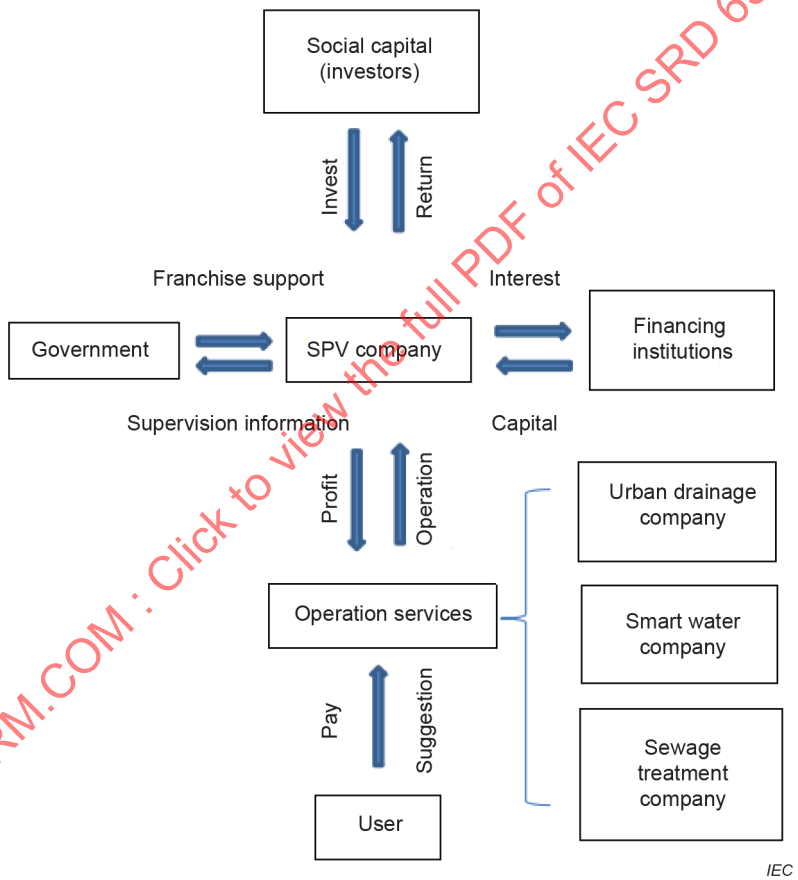


Figure 7 – Relationship between stakeholders

The SPV (special purpose vehicle) company provides comprehensive smart drainage solution for operation service providers oriented to users, supervised by the government, while receiving investment from social capital and financing institutions, see Figure 7.

7.5.7 Scenarios

Take the Wuhan city for example. A deep drainage transmission system project in the core area of East Lake has been built to improve urban drainage capacity, eliminate overflow and rain pollution, and improve the urban water environment. The project collects sewage from central areas in the city and transfers it to the Beihu sewage treatment plant in the suburbs through a deep tunnel system.

The project operates a smart drainage transmission system based on sensors and automation processes to monitor and respond to changes in drainage flows.

7.5.8 Requirements

In light of application model of smart water drainage system, the following issues shall be taken into consideration:

– online monitoring technology;
– smart water IoT;
– GIS platform;
– waterworks automatic control;
– neural network model;
– big data model;
– simulation model;
– smart inspection system;
– asset management system;
– performance appraisal system.

7.6 Resilience-based flood management and prevention

7.6.1 Need statements

To effectively reduce the exposure and vulnerability of disaster-bearing entities and individuals in cities in the event of flood disasters and strengthen the city's ability to rapidly recover from disasters.

7.6.2 Objectives

The objectives for resilience-based flood management and prevention include the following.

- Upgrade the existing flood management and prevention scheme, upholding a resilience-based model.
- Foster a smart sponge city model to achieve optimal allocation and efficient use of urban water resources.

7.6.3 Current practices

The concept of resilience was first studied and applied in ecology and engineering, where it has been a focus for a long time; but its application in natural disaster management has only begun over the past decade, during which a lot of work has been done on resilience planning and construction to cope with the pressure imposed by climate change and others by multiple countries. The United Nations Office for Disaster Risk Reduction (UNDRR) clearly stated that by 2030, the world should reduce the damage of disasters to major infrastructures greatly by improving resilience.

Against such a background, the traditional flood management methods driven by vulnerability reduction have begun to shift to a resilience-based approach internationally, so as to cope with the rapid urbanization and climate change more effectively.

The resilience-based flood management is regarded as a more forward-looking approach and featured as a systematic approach by coupling multiple links, processes and responses of flood management.

7.6.4 Gaps

The traditional flood management approach focuses on changing the movement and path of floodwater through water projects (such as dams, embankments and other measures), in addition to non-engineering measures such as forecasting and scheduling. In the event of a disaster, the ability of disaster-bearing body to resist, adapt to and recover from the flood disaster is poor, which often leads to a long-term "paralysis" of the city, resulting in huge economic and social losses.

Furthermore, affected by climate change and massive human activities, the traditional water projects and municipal pipe network construction can hardly resolve the urban flooding caused by frequent and extreme rainfall effectively. It is important to re-examine the relationship between humans and water as well as city and water, and to build a new urban development system in which the city is a sponge, resistant to flood and able to co-exist and integrate with water. Therefore, the urban renewal should start from the perspective of resilience.

7.6.5 Stakeholders

– Stakeholder 1: the department of water supply
  - Description: responsible for the operation and management of public water works in the city
  - Role: Primary beneficiary or designer or user
– Stakeholder 2: the department of urban drainage
  - Description: responsible for the operation and maintenance of drainage systems
  - Role: Primary beneficiary or designer or user
– Stakeholder 3: the department of urban drainage
  - Description: responsible for the regulation and management of drainage systems
  - Role: Primary beneficiary or designer or user
– Stakeholder 4: the department of sewage treatment
  - Description: responsible for the operation and management of urban sewage treatment plants
  - Role: Primary beneficiary or user.
– Stakeholder 5: the transportation sector
  - Description: responsible for the operation, scheduling and management of city transportation
  - Role: Secondary beneficiary
– Stakeholder 6: the department of power supply
  - Description: responsible for the urban power supply
  - Role: Secondary beneficiary
– Stakeholder 7: the department of natural gas supply
  - Description: providing natural gas supply to the city
  - Role: Secondary beneficiary
– Stakeholder 8: the department of telecommunications
  - Description: responsible for the telecommunication services of the city
  - Role: Secondary beneficiary
– Stakeholder 9: school presidents
  - Description: responsible for education and management of the school
  - Role: Secondary beneficiary

– Stakeholder 10: administrators of hospitals
  - Description: responsible for medical work and management of the hospital
  - Role: Secondary beneficiary
– Stakeholder 11: managers of malls
  - Description: responsible for daily operation and management of the mall
  - Role: Secondary beneficiary
– Stakeholder 12: citizens
  - Description: responsible for protecting personal property and daily life from flood disaster
  - Role: Primary beneficiary

7.6.6 Relationship between the stakeholders

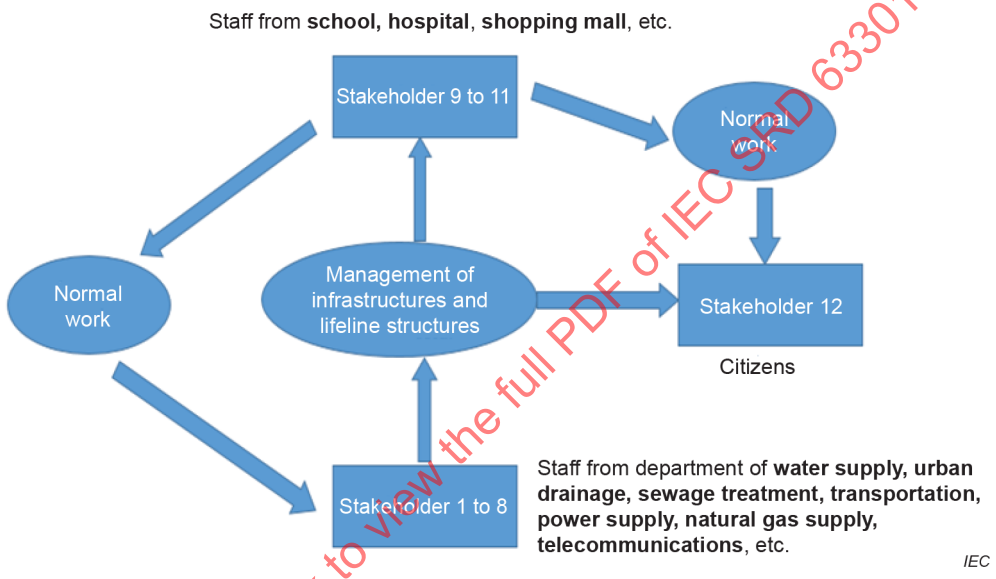


Figure 8 – Relationship between stakeholders

Stakeholders 1 to 8 are responsible for the operation and management of major infrastructures and lifeline structures of a city to guarantee the normal work of Stakeholders 9 to 11 and the normal life of Stakeholder 12, see Figure 8.

The normal work of Stakeholders 9 to 11 provides corresponding social functions for Stakeholders 1 to 8 and 12.

7.6.7 Scenarios

Resilient city construction can ensure the supply of electricity and water, the transportation as well as the safety of basement, underground garage and other underground space in flood season at the community level.

It also helps improve the city's ability to drain rapidly and recover from the flooding at the management level, thus reducing social and economic losses to a certain extent, which has been testified in a lot of countries. In 2019, the UK proposed the Property Flood Resilience Action Plan to strengthen the protection of back-end disaster-bearing bodies, supported by financial products including flood insurance and reinsurance. The Canadian government proposed to build "resilient communities" to improve the ability of Canadians to cope with the pressure imposed by climate change and others.

7.6.8 Requirements

For this HLUC the following issues shall be considered.

– Data: Literature research and data collection are needed to build a resilience theory framework and establish a resilience assessment system.

– Tools: A set of model tools is required to analyse and evaluate the function, effect and layout of urban flood resilience.

– Facilities: The materials and equipment are needed for housing structure renovation, underground space entrance reconstruction, lifeline engineering renovation, urban rapid drainage facilities construction and so on.

7.7 Flood management and prevention

7.7.1 Need statements

To reduce the impact of flood hazards to ensure that the city is liveable and resilient to attract investment and is safe from harm to people and property.

7.7.2 Objectives

The objectives or goals of the smart technology investment in relation to flood management and prevention include the following.

- Monitor and manage the levels and frequency of floods in urban habitats.
- Take various prevention and control measures to resist and reduce the catastrophic losses caused by flood to the city,

7.7.3 Current practices

The problems in existing practice that will necessitate the implementation of smart technology are the following.

– Forecast flooding incidences using weather forecasts.

– Collect and manage real-time monitoring data and video, to understand flooding incidence and show the information base on GIS platforms.

– Issue early warnings and updates to various stakeholders.

– Build IT infrastructure including communications network, cloud computing platform and SCADA system.

7.7.4 Gaps

The gaps for implementing effective flood management and prevention mainly exist in:

– monitoring of condition and resources related to flood management;

– data collection, management and dissemination;

– prioritization and smart-allocation;

– inclusion of the most vulnerable.

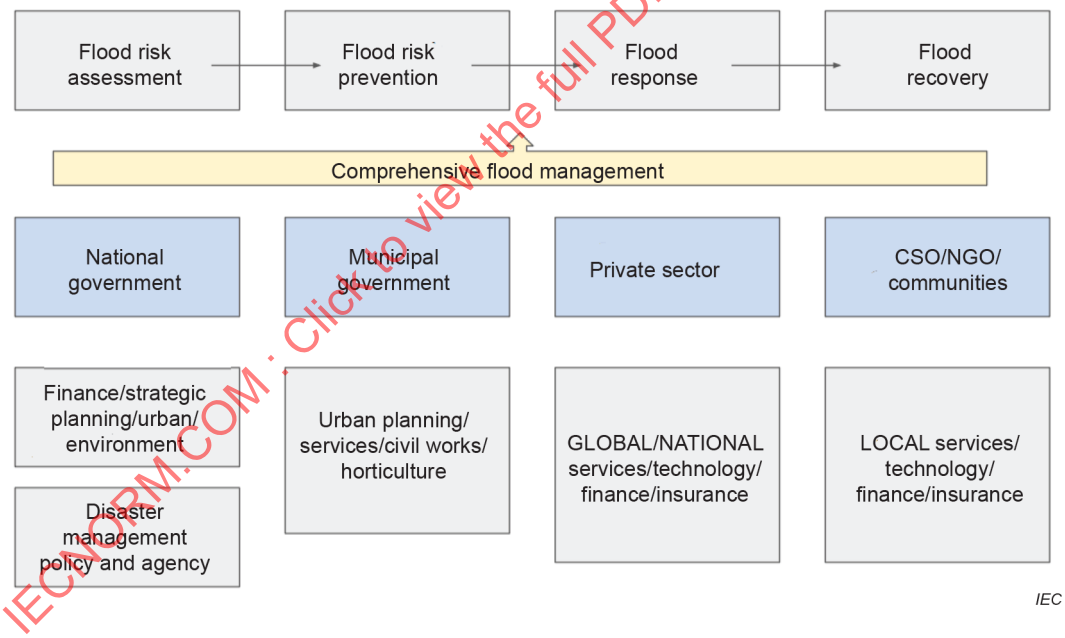
7.7.5 Stakeholders

– Stakeholder 1: Disaster management authorities

  - Description: working with national, regional and local stakeholders to build plans, systems, capacity and infrastructure that help to avoid floods
  - Role: Primary beneficiary or designer or user

– Stakeholder 2: municipal government
  - Description: plan and build capacity and infrastructure with collaboration from other stakeholders
  - Role: Primary beneficiary or designer or user
– Stakeholder 3: flood management department
  - Description: in charge of the regulation and management of drainage systems
  - Role: Primary beneficiary or designer or user
– Stakeholder 4: communities or citizens
  - Description: avoid any loss to life and livelihood resulting from floods
  - Role: Primary beneficiary or user.
– Stakeholder 5: Private sector and businesses
  - Description: provide services for flood management at a cost, promote the availability of innovative services
  - Role: Secondary beneficiary
– Stakeholder 6: Media and social media
  - Description: disseminate forecast and information about floods
  - Role: Secondary beneficiary

7.7.6 Relationship between the stakeholders



Key

CSO civil society organization

NGO non-governmental organization

Figure 9 – Relationship between stakeholders

All of the stakeholders including national government, municipal government, private sector and others take part in comprehensive flood management covering flood risk assessment, flood risk prevention, flood response and flood recovery, see Figure 9.

7.7.7 Scenarios

Numerous cities in South Asia such as Khulna (Bangladesh), Chennai (India), and HCMC (Viet Nam) suffer from several types of regional and localized flooding.

In collaboration with the private sector and others, the national government and municipal government have actively mobilized resources to respond to disaster emergencies, including providing relief supplies, medical assistance, temporary shelter, etc., and strengthening the construction of disaster early warning systems. These combine to serve to improve the construction of flood control facilities and promote flood insurance, thus effectively reducing the impact of flood disasters.

7.7.8 Requirements

For this HLUC following requirements apply.

Information exchange: A wider-area disaster information sharing mechanism shall be established to realize the rapid transmission and sharing of disaster information.

International cooperation: Faced with the common challenges brought by cross-border flooding, countries shall strengthen international cooperation and exchanges to share experience, technical assistance and financial support to jointly address the challenges of natural disasters.

7.8 Flood control and relief

7.8.1 Need statements

To master the overall conditions of flood routing, make benefit-maximizing decisions in different conditions to avoid and reduce flood-induced damage and losses.

7.8.2 Objectives

The major objectives for the smart water solutions regarding flood control and relief in cities include the following.

- Strengthen the capacity of perception and acquisition of water-related data and information.
- Optimize water utilization structure and improve the water use efficiency.
- Reduce water use costs of water-users and operating costs of waterworks and water treatment plants, etc., increase returns of the water industry.
- Enhance emergency response capacity to water-related disasters and decrease disaster losses.

7.8.3 Current practices

The evolution of society and technologies have paved a smooth path for flood control and relief in a smarter and more efficient way.

- Transformation of water governance system from multi-sectorial management to integrated management system (governance system).
- Development and maturity of IoT and ICT technology (advanced technology).
- A solid foundation of water informatization in the past 20 years.
- People's desire and pursuit for a better and water-friendly society.

7.8.4 Gaps

The gaps for flood control and relief in smart city mainly exist in:

- monitoring of condition and resources related to flood management;
- data collection, management and dissemination;
- prioritization and smart-allocation;
- inclusion of the most vulnerable.

7.8.5 Stakeholders

– Stakeholder 1: Flood control and drought relief headquarters (county-level)
  - Description: office responsible for flood control and drought relief
  - Role: Primary beneficiary or designer or user
– Stakeholder 2: Members of flood control and drought relief headquarters
  - Description: guided by the headquarters, work in cooperation to reduce flood hazards and maintain social order
  - Role: Primary beneficiary or designer or user
– Stakeholder 3: Local entities
  - Description: be informed about the flood-related information and take timely actions to avoid great losses
  - Role: Primary beneficiary or user
– Stakeholder 4: Citizens
  - Description: be informed about the flood-related information on time
  - Role: Primary beneficiary or user
– Stakeholder 5: Property and casualty insurance companies
  - Description: responsible for assessment of flood occurrence possibilities and possible damage
  - Role: Secondary beneficiary

7.8.6 Relationship between the stakeholders

Stakeholder 1 and stakeholder 2 are responsible for implementation of the solution, supported by stakeholder 5, serving and engaging stakeholder 3 and stakeholder 4.

7.8.7 Scenarios

River flood prevention is closely related to urban waterlogging and urban safety.

To protect the urban safety downstream during flood season, a city usually sacrifices its benefit by storing floodwater in its detention basin. Smart technology, accurate flood forecasting, better floodwater resource utilization, and remote gate control could reduce the sacrifice of the water detention area.

7.8.8 Requirements

For this HLUC following issues shall be considered:

- flood prevention and drought relief management (water safety);
- integrated water resource management (water resources);
- water conservancy projects management;
- integrated water supply system;
- multi-purpose water utilization and water-saving strategy;
- integrated water drainage and water treatment system;
- water ecology and water environment system.

7.9 Intelligent manhole cover monitoring system

7.9.1 Need statements

To realize instant monitoring and report of manhole status, ensuring travel safety of people and vehicles transiting above.

7.9.2 Objectives

The objectives for intelligent manhole cover monitoring system include the following.

- Realize real-time monitoring, positioning, data sharing, intelligent decision-making for manhole cover operation through the intelligent monitoring system.
- Implement manhole cover monitoring system by deploying sensing devices in an efficient way.

7.9.3 Current practices

The continuous urbanization brings about various municipal underground pipelines transporting water, sewage, gas, heating, electricity, communications across cities; correspondingly, inspection wells are also rapidly spreading along the pipelines, so that management of urban manhole covers is becoming more and more important.

The inadequate management of manhole covers has seriously affected the personal safety of citizens and caused negative social impact. How to improve and strengthen the management of urban manhole covers has become a difficult and hot issue troubling municipal facilities management departments across cities.

7.9.4 Gaps

At present, the inspection work of manhole covers mainly relies on manual inspection, which is inefficient and resource-consuming.

- Failure to discover in time: When the manhole cover is displaced or tilted, it cannot be detected in time, only to be found by passers-by or manual inspection.
- High potential safety hazards: In recent years, there have been many safety accidents caused by the damage and displacement of manhole covers all over cities.

7.9.5 Stakeholders

– Stakeholder 1: Water company, government department

  - Description: responsible for the operation and maintenance of manhole covers, project investment and construction
  - Role: Primary beneficiary or designer or user

– Stakeholder 2: Project contractor
  - Description: the various departments, guided by the headquarters, work in cooperation to reduce flood hazards and maintain social order
  - Role: Primary beneficiary or designer or user
– Stakeholder 3: Smart water service provider
  - Description: provide intelligent products and software systems and provide technical guidance.
  - Role: Primary beneficiary or user

7.9.6 Relationship between the stakeholders

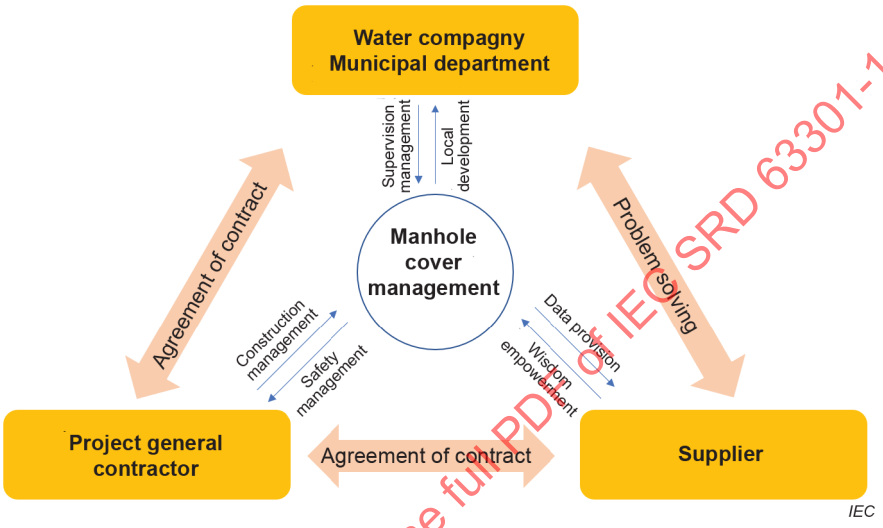


Figure 10 – Relationship between stakeholders

The relationship between stakeholders is shown as Figure 10.

7.9.7 Scenarios

The intelligent manhole cover monitoring system mainly manages and maintains manhole covers through the following functions.

- Positioning and monitoring: various types of status information of manhole covers can be monitored in real time, through the monitoring system.
- GIS mapping: the position, basic information and real-time status can be displayed on the electronic map.
- Alarming: the alarm information of the manhole cover can be transmitted to the manhole cover monitoring system, which will then send prompts to relevant responsible persons and managers in time.

7.9.8 Requirements

To ensure desired performance of the intelligent manhole cover monitoring system, the following requirements apply.

- On one hand, manhole cover condition monitors and other IoT sensing devices shall be dynamically deployed to obtain real-time information about the manhole cover status, and effectively realize timely alarms for abnormal manhole covers.
- On the other hand, the deployment of monitors and sensing devices shall be cost-controllable and technically feasible.

7.10 Water data platform and cyber physical systems for urban water cycle management

7.10.1 Need statements

To improve general efficiency of urban water cycle in terms of both quantity and quality, through an integrated water data platform.

7.10.2 Objectives

The objectives of urban water cycle management system, which includes water data platform and cyber physical systems (CPS), are as follows.

– Connect water distribution and sewerage networks to understand water usage patterns and amount of consumption.
– Evaluate healthiness of water cycle in urban catchment.
– Build IT infrastructure including cloud computing platform, measuring system and emergency response plan.
– Visualize water flow such as water intake, purification, distribution, consumption, sewage treatment, and reuse process through graphic user interface inside CPS platform.
– Respond to the abnormal and emergency condition about water usage, enabling a city to provide stable and clean water supply with lower energy cost.

7.10.3 Current practices

Many cities in the world are facing water quantity and quality problems.

– Quantity: Due to the extensive impervious area in the cities, the amount of infiltration is smaller than that of natural watershed, so groundwater level is decreased and flood damage downstream becomes severe. Also, due to the increasing population, per capita water consumption in the city increases. Therefore, water consumption is monitored to control water usage.
– Quality: Initial rainfall runoff in the city is usually contaminated; therefore, filters are required to treat initial rainfall. To solve this problem, low impact development (LID) facilities have been installed in the city. In addition, the water quality of urban rivers is deteriorating. Therefore, it is important to monitor and regulate the effluent water quality from wastewater treatment plants, and, if necessary, propose regulation and new standard for effluent water quality.

7.10.4 Gaps

The urban water cycle begins with water extracted from rivers and aquifers, usually stored in water reservoirs and then processed to potable quality via water treatment plants before delivery through a water distribution pipe network to water users. After being used, some of the water is transported to wastewater treatment plants through a network of sewers, then effluent is discharged into rivers again. Each component in the urban water cycle has been managed as separate system. However, the efficiency of urban water cycle cannot be improved if those components are operated individually, and also water quality and quantity problems occurring in a city would still be difficult to solve. Therefore, a water data platform for water quantity and quality in each component of urban water cycle is required and the urban water cycle management should utilize all the data managed by the platform.

In this use case, which is deployed in South Korea, Water DNA (data, network, and artificial intelligence) as water data platform and CPS have been deployed.

7.10.5 Stakeholders

– Stakeholder 1: municipal governments
  - Description: to protect the water environment and work out water diversion plan and supervision of the water transfer activity and to receive and treat the sewage transmitted. Also, to protect the river, to ensure that water quality and quantity are up to regulations and guidelines. Based on water data platform, to realize the optimal operation situation between reservoirs
  - Role: Primary beneficiary or designer or user
– Stakeholder 2: water service providers
  - Description: to intake water from a river, treat then supply purified water to the city. Also, responsible for the operation of the surface drainage pipe network, to collect sewage in the deep drainage transmission system
  - Role: Primary beneficiary or designer or user
– Stakeholder 3: citizens
  - Description: to get the information about drinking water
  - Role: Primary beneficiary or user
– Stakeholder 4: ICT solution providers
  - Description: to provide solutions for water data integration, management analytics (e.g. water DNA platform) and simulation (e.g. CPS).
  - Role: Primary beneficiary or user

7.10.6 Relationship between the stakeholders

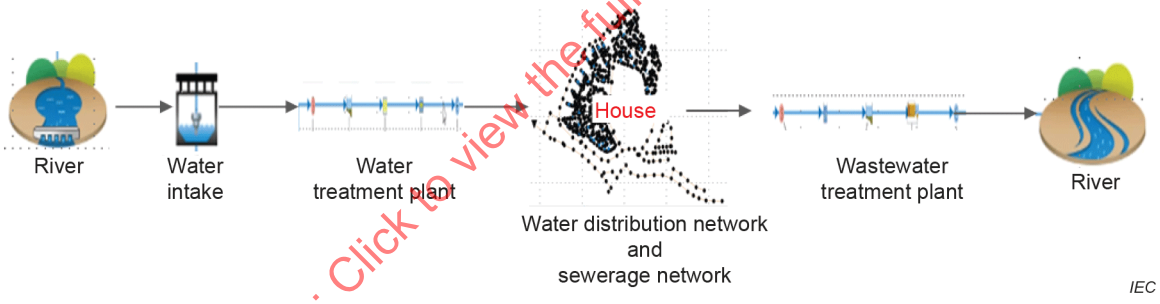


Figure 11 – Relationship between stakeholders

Municipal governments supervise water service providers to see whether they comply with the regulation and local standard.

ICT solution providers measure and produce water quantity and quality data and provide the data to water service providers, see Figure 11.

7.10.7 Scenarios

Take the Sejong city for example. Sejong's drainage network has been built for a new residential development. An urban drainage capacity was designed to prevent urban flood and LID facilities were constructed to reduce pollution from initial rainfall.

With the water DNA platform, water demand, water consumption and water quality data can be collected from existing water infrastructure and IoT sensors. The water data is then used by CPS for water issue analysis, event decision commanding of water utilization, water discharge and pollution control.

7.10.8 Requirements

The following issues shall be considered in the management of urban water cycle.

1) Acquisition of data:
   – standard-based interoperable data platform: water DNA that provides standard application programming interfaces (APIs) and common water data models.
2) Integrated urban water cycle system:
   – water flow analysis modelling for quantity and quality;
   – integrated modelling platform.
3) Regulation and policy:
   – water distribution and management policy;
   – technical and operational guides for water service providers.

8 Conclusions and recommendations

Countries face a variety of diverse local factors related to water management such as hydrological condition, geography, climate, weather patterns and population density. Despite this there are some common water management needs that have been identified.

The most significant concerns and needs are as follows.

a) Separately managed component in the urban water cycle is impacting operational efficiency and water quality and quantity, it also limits incident management and triage across urban cities and communities.
b) Multiple governing bodies and agencies have unclear roles, responsibilities and accountabilities further impacted by unconscious bias to not support local infrastructure via the "not in my backyard" phenomenon, creating both inefficient infrastructure, systems and information sharing that in turn affects operational excellence.
c) Untimely information about water quality or flow hinders a timely inexpensive response.
d) Limited communication and collaboration between water organizations, government agencies, communities and citizens limits optimized and proactive operation, management, consumption, re-use and disposal of water resources for citizens, stakeholder organizations and the natural environment.

As smart technologies evolve and deploy at massive rates with the Internet of Things and big data, there are many examples of the use of smart sensor-based networks designed to optimize water supply and use. Typical measures include:

1) Technical means
   - Establish a strong and environmentally friendly infrastructure and framework that monitors the conditions of natural water bodies that include rivers, reservoirs, lakes, among others, and supports corresponding corrective actions.
   - Collect and manage real-time monitoring data and video, to gather valuable insights to better manage deep drainage tunnels.
   - Formulate comprehensive water dispatch and economic operation strategies for each pre-treatment station in the deep tunnel by comparing and analysing multi-dimensional big data.
   - Realize comprehensive secure online systems to manage and control deep drainage tunnel operation data, operation and maintenance controls and proactive ideally automated maintenance works.

2) Active administration

- Establish a water-manager system with federated levels of administration (provinces, cities, counties, and townships) to assign safe river management to responsible persons.
- Establish regulations and permit systems for industrial waste discharge and pollutants. The permit should specify requirements such as the type, concentration, total amount and discharge destination of the water pollutants discharged and any approval should be independently verified for environmental and public health impacts.

3) Making greatest use of water resources and taking water conservation measures

- Establish water conservation plans that encourage prudent water uses such as mandatory water efficiency labelling schemes, water closet replacement programme, water efficiency awards for both domestic and non-domestic sectors.
- Water agencies conservation requirements as regulated by the state must consider local needs and characteristics.
- New commercial and residential buildings should meet the highest levels of water efficiency with simple rating systems for taps, shower heads, appliances tied to development approvals such as the installation of water-efficient tap flow filters and use of rainwater or greywater systems. Examples include the WELS scheme in Australia, S-CAD method in China, Water Sense in the USA and Waterwise in the UK, voluntary taps and valves scheme in Europe known as CEIR and EU Ecolabel for appliances.

Annex A
(informative)

List of stakeholders and description

Table A.1 – List of stakeholders and description

Identifier	Organization	Name of stakeholder or actor	Description	Role in city
Wa_01	Water managing authority	water quality monitoring officer	Officer that monitors the water quality (rivers, lakes)	Responsible for monitoring the water quality, water volume, water surface cleanliness and water activities (to enforce any prohibition of mining, fishing, etc.) of rivers and lakes
Wa_02		Sewage outflow monitoring officer	Officer that monitors the quality of sewerage outflow	Responsible for continuously monitoring quality, discharge volume and discharge index of sewerage discharge and for taking appropriate action should there be a pollution event
Wa_03		Comprehensive management officer	Officer handling management of the water quality on a daily and comprehensive basis	Responsible for managing and presenting the comprehensive status of rivers and lakes, carrying out daily inspections and cleaning
Wa_04		Officer for emergency handling	Officer handling water-related emergency incidents	In case of emergency incidents, to promptly notify and coordinate the relevant departments to deal with the reported emergency incidents, and give feedback on the results of the disposal
Wa_05		Water bureau officer	Officer that monitors the water quality, sewage discharge and manages water resources	Responsible for monitoring quality, discharge volume, protecting water resources (rivers, lakes, etc.) and for taking appropriate action to prevent pollution
Wa_06		Construction bureau officer	Officer that monitors the construction quality of the water drainage project	Responsible for guiding the city planning, managing the city's construction activities, monitoring quality of construction projects

Identifier	Organization	Name of stakeholder or actor	Description	Role in city
Wa_07	Department of water supply	Water supply manager	Manager that operates and manages urban water supply systems	Responsible for monitoring the water pressure and quality, and maintaining the water supply equipment
Wa_08	Department of urban drainage	Drainage system maintenance manager	Manager that operates and maintains urban drainage systems	Responsible for operating pump stations, gates, etc. and maintaining the drainage pipelines
Wa_09		Drainage system regulation manager	Manager that regulates and manages urban drainage systems	Responsible for scientifically and integrally regulating the urban drainage systems and coordinating flood storage, retention and infiltration structures to work
Wa_10	Department of sewage treatment	Sewage treatment manager	Manager that operates and manages urban sewage treatment plants	Responsible for keeping the sewage treatment running normally, and ensuring the treated water quality reaches certain standard
Wa_11	Urban drainage company	Company manager for pipe network management	Responsible for the management, scheduling and maintenance of the overall urban drainage system including the urban sewage pipe network	Responsible for collecting the information about sewage collection and transmission capacity of the deep tunnel system, adjusting the drainage route of the surface pipe network
Wa_12	Sewage treatment company	Company manager for quality of sewage treatment	Person who is in charge of the quality of sewage after treatment	Responsible for managing sewage discharge and ensuring discharged sewage meets the requirements of standards and regulations
Wa_13		Company manager for general management	Person who is responsible for the daily operation of sewage plant	Responsible for processing daily sewage of the city and ensuring the treatment function is running well
Wa_14	Sewage discharge company	Company manager for external affairs	Person who reports on the quality of sewage discharge	Responsible for keeping the city government water department updated on the quality of sewage discharge
Wa_15		Company manager for internal affairs	Person who manages sewage discharges	Responsible for managing sewage discharge to assure conformity to standards and regulations

Identifier	Organization	Name of stakeholder or actor	Description	Role in city
Wa_16	Department of transportation	Transportation regulation manager	Manager that operates, schedules and manages the urban transportation	Responsible for keeping the road network in a good state, and the transportation running normally
Wa_17	Department of power supply	Power supply manager	Manager that manages the urban electricity supply	Responsible for keeping substations and terminal power transformation and distribution facilities running normally
Wa_18	Department of natural gas supply	Natural gas supply manager	Manager that manages natural gas supply to the city.	Responsible for keeping gas supply stations and the gas pipeline running normally.
Wa_19	Department of telecommunications	Manager for telecommunication affairs	Manager that manages the telecommunication services of the city	Responsible for keeping the base stations for telecommunication and the optical cable running normally
Wa_20	Schools	Headmaster	The director in charge of the education and management of the school	Responsible for keeping teaching activities running normally, and keeping the students' life in the school safe
Wa_21	Hospitals	Director of the hospital	The director in charge of routine medical work and management of the hospital	Responsible for keeping routine medical work running normally
Wa_22	Shopping malls	Manager of the shop	Manager that operates and manages the shopping mall	Responsible for keeping the shopping mall running normally
Wa_23	Residential buildings	Citizens	Average citizens	Responsible for obtaining water-related information, and for reporting emergency incidents
Wa_24	SPV (special purpose vehicle) company	Project manager	SPV company is a company under PPP (public private partnership) mode, specially registered in the place where the project is located for the operation of the project. It is independently responsible for the financing, construction, operation and management of the project.	In PPP mode, comprehensively responsible for the project design, investment and financing, construction, operation and maintenance and handover