PROMOTING ENVIRONMENTALLY SUSTAINABLE SMART CITIES

15–18 October 2018, Seoul

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ADB, KEITI, and K-water

PROMOTING ENVIRONMENTALLY SUSTAINABLE SMART CITIES

"Environmental problems are not limited to a single country. They can be regional or global in scale. Our future and environment are entirely dependent on what we do today. Tomorrow is built today. This workshop will serve to share ideas and solutions to national and international urban and environmental problems."

Mr. Kwanghee Nam,
President, Korea Environmental Industry & Technology Institute

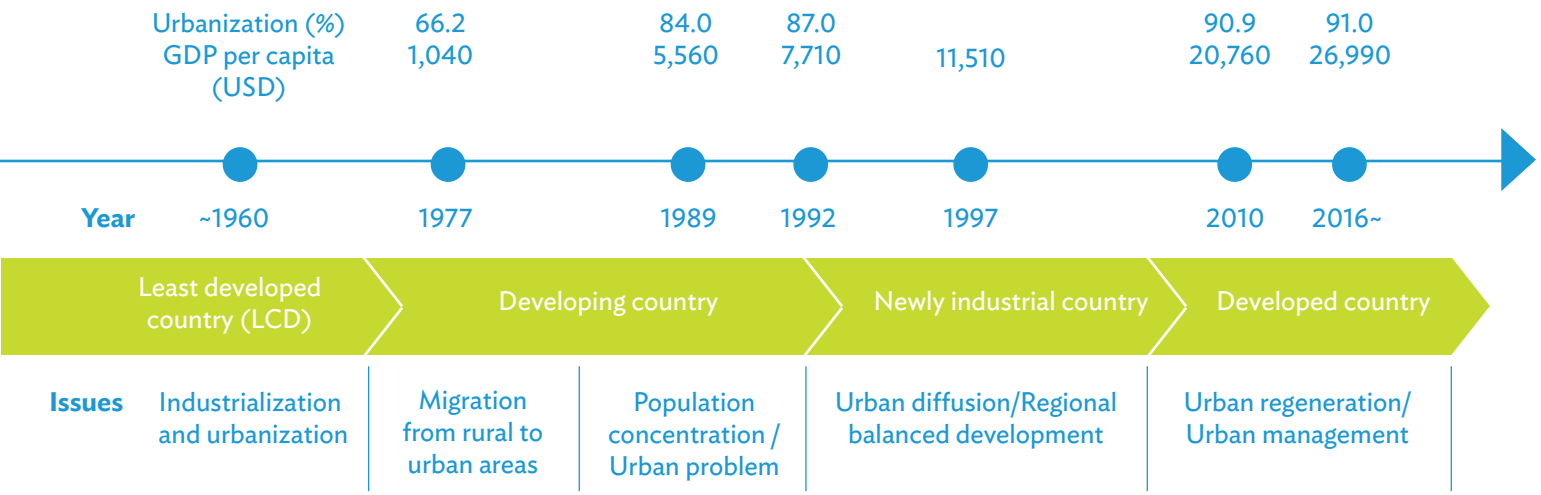
Asian cities are expected to accommodate another 1 billion people within the next 2 decades. Cities drive economic growth, but rapid urbanization is threatening the quality of life and degrading environmental systems. Many South Asian cities already face challenges of environmental degradation, inadequate urban infrastructure and services, and inefficient management systems.

As a newly developed country, the Republic of Korea (ROK) has recently emerged from a period of rapid urban and economic growth and is now ready to share important lessons learned through this process. The Government of the ROK and associated agencies continue to innovate in developing policy and technology for managing urban growth in a sustainable way.

A workshop organized by the Asian Development Bank (ADB), Korea Environmental Industry and Technology Institute (KEITI), and Korea Water Resources Corporation (K-water) provided a platform to share this knowledge and experience in managing urban challenges through integrated smart city approaches.

Delegates came from Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka to learn from ROK experts in smart systems, while also sharing numerous examples of successful smart initiatives across South Asia. This collaborative approach enabled cross-pollination of ideas, accelerating the evolution of best practices for smart city implementation in ADB developing member countries.

ROK NATIONAL GROWTH PROCESS



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ROK URBAN DEVELOPMENT GROWTH PROCESS

WHAT IS A SMART CITY?

Smart systems are those that apply technology to gather and integrate information to improve operational decision-making and efficiency. Smart, however, does not necessarily mean high tech. Information and communication technology (ICT) in itself is not smart; it is a tool to facilitate smart solutions. As noted by Mr. Youngjune Choi[1], smart is not fixed; smart is dynamic. What is smart now may not be smart in the future. And what is smart in the ROK may not be smart in South Asia.

A smart city integrates services previously configured individually and automates systems to become more efficient. In this way, technology can be deployed to reduce costs, promote equity, strengthen resilience, and ensure sustainability.

Workshop participants learned that smart city developments in the ROK have been underpinned by long-term policy development and investment, recognizing the value of the urban environment in improving the quality of life and delivering inclusive growth. The focus of this workshop was on smart city approaches to:

- urban development policy,
- urban water supply,
- wastewater management,
- municipal solid waste management, and
- urban transport, safety, and security.

1 General Manager, Seoul Metropolitan Government.

FACILITIES VISITED AND HIGHLIGHTS

K-water: Hangang Water Supply Operations Center
- Automated, integrated water resource-management facility
- Bulk water-supply operations center for the Seoul metropolitan area

Anyang City Hall: Transportation and Operations Center
- Traffic flow and safety management
- Bus operations and management
- Citizen safety and security

Hanam City: Union Park Underground Waste-Management Facility
- Not in my backyard (NIMBY)-proof underground facility
- Wastewater treatment
- Materials recovery and recycling center
- Waste-to-energy incinerator
- Food waste-to-animal feed processing

Daejeon: K-water Headquarters
- National water resources management center
- Water quality research center and laboratory

Daechung Multipurpose Dam
- 84-meter-high concrete and rock-fill dam
- 90,000 kilowatt generation capacity
- 1.5 billion cubic meter (m^3) storage capacity
- 20,000 m^3/second maximum spillway discharge

Songdo: Incheon Free Economic Zone Smart City Operations Center
- Greenfield smart city and free economic zone
- Integrated smart city operations center
- On-site public cloud data storage

KEITI Incubation Center
- Turnkey research and development facility
- Laboratories, test beds, and research support facilities

Sudokwon Landfill
- Largest landfill globally
- Integrated recycling and resource-recovery facility
- Waste-to-energy facilities for 340 million kilowatt-hours per year
- Leachate treatment, sludge recovery, and food waste processing
- Landfill restoration for tourism and public amenity

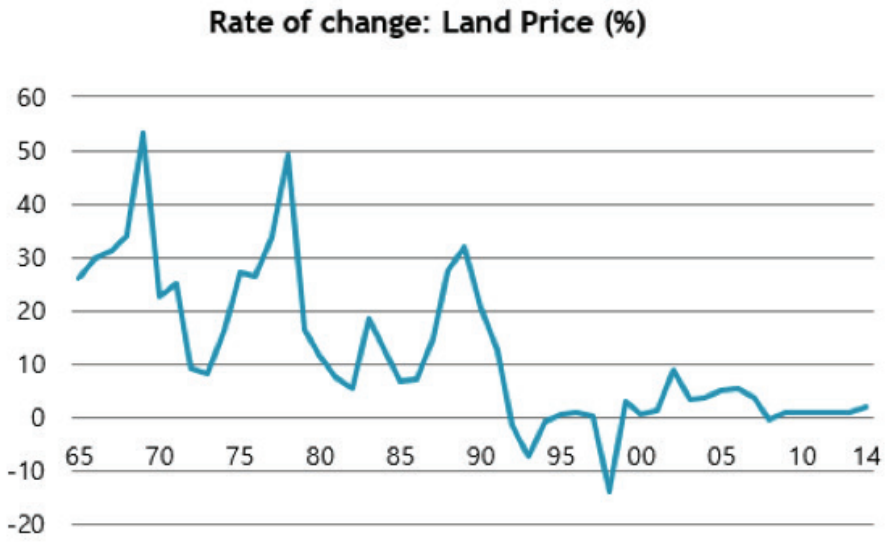
URBAN DEVELOPMENT POLICY IN THE ROK: TOWARD SMART CITIES

The national urban strategy of the ROK now supports balanced urban development. Immediately after the Korean War, however, it stressed industrial growth and housing a workforce to enable this growth.

In the event, housing supply fell woefully short, meeting less than half of demand from a rapidly urbanizing population. One result was land and property speculation. Another was the formation of large peri-urban slums.

Joon Park[2] described the government's response as land-use planning designed to increase the supply of urban land, stabilize property prices, and subsidize affordable housing.

A mismatch in housing demand and supply in the ROK in 1965–1980 spurred land and property speculation that fueled price volatility. Policies implemented since then have stabilized land prices.

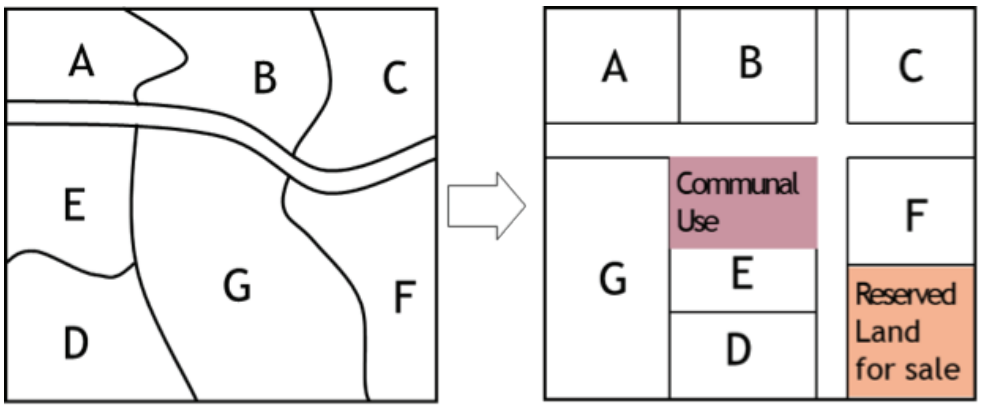


2 School of Urban Sciences, University of Seoul.

Land readjustment involved negotiating a number of private land lots and replotting them for development with improved infrastructure. This increased land values for the original landowners. The resulting areas include plots for communal use and land reserved for sale to finance the scheme.

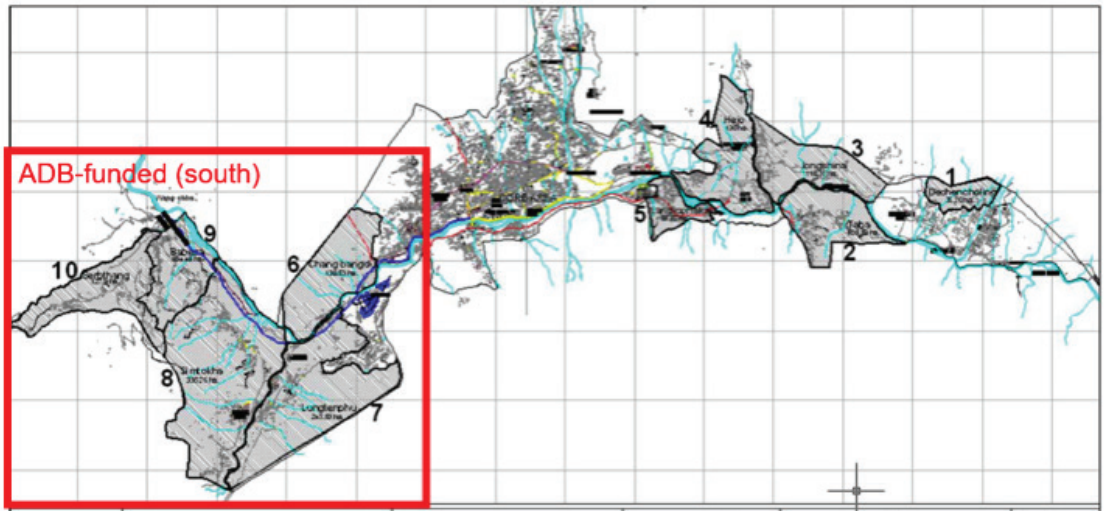
LAND READJUSTMENT

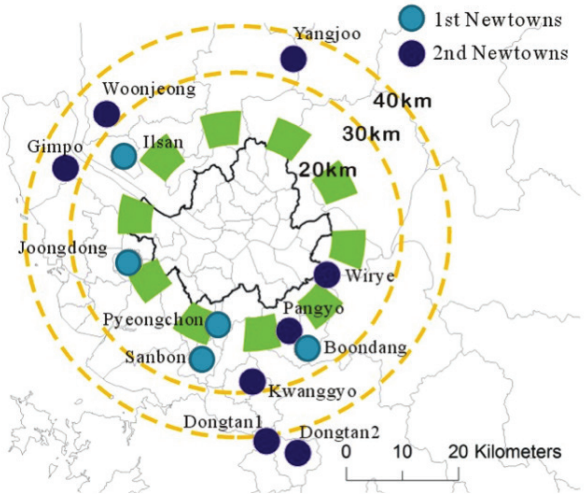
The government used a land readjustment scheme to make available more developable urban land. Under a self-financing exchange-based method, the land under negotiation was pooled, replotted, and redeveloped with improved infrastructure and space reserved for communal amenities and services. Development was undertaken by both public and private entities, and some land was allocated to the developer to enable cost recovery.



Under this scheme, the increased land value is returned to the individual landowners. A disadvantage was that was that little thought went to enhancing community quality of life. Another was that negotiations with landowners were long and challenging.

In Bhutan, ADB has supported a similar land-pooling process for sustainable urban expansion in Thimpu, a city with significant land constraints. Public land acquisition for urban expansion was not feasible because of the high cost of land. In 2003, the municipality planned 10 new local area plans (LAPs) for expanding the city. Under the ADB-supported Urban Infrastructure Development Project (2007–2016), land pooling was used to provide serviced land in four southern LAPs, which were previously paddy fields. Under the project, about 727 landowners voluntarily pooled their agricultural land for urban expansion, yielding up to 30% of their land to the government in exchange for serviced land of higher value. The approach was later replicated in the LAPs in northern Thimphu with World Bank financing support. The success of this approach was made possible by Bhutan's strong tradition of urban planning and land management. This case study was presented at the workshop by Shinjini Mehta, ADB, and Jigme Dorji, ADB project manager, Ministry of Works and Human Settlements, Bhutan.





The first phase of new town development in the Seoul metropolitan area, implemented in 1980–2000, generally occurred within 30 kilometers of the city center. In the second phase, new towns were up to 50 km away.

NEW TOWNS

In the 1980s the government developed the New Towns Program, a new mechanism to provide urban land and housing with more social equity, and without huge land value increases.

The approach involved the development of new towns through a publicly managed vehicle. The new towns program was mainly used for greenfield development of new satellite towns around Seoul. Land was expropriated from landowners if negotiations were not successful, which required new legislation in the form of the Land Acquisition and Compensation Act.

Social housing schemes were included in the towns, and financial support was provided to first-time buyers. The scheme enabled the development of well-functioning cities housing millions of people, and the development gain was better distributed across society, rather than benefitting mainly the original landowners.

Criticism of the scheme highlighted environmental degradation with greenfield development, monotonous urban design, and the new towns' considerable distance from Seoul.

BALANCED URBAN DEVELOPMENT

In the new millennium, central and local governments began to build new towns with diverse policy goals: improving living standards, balancing national development, and revitalizing the economy.

- The nine second-phase new towns in the Seoul metropolitan area focused on creating a better living environment and improving environmental management.
- New administrative cities, now under construction, will accommodate ministries and research institutes.
- Ten innovation cities have been identified for accommodating government agencies relocated from the Seoul metropolitan area.
- Eight free economic zones aim to enhance national competitiveness by attracting foreign investment.

"Smart is about solving problems, so we should start with the problems. In our cities, these are congestion, pollution, inequality...

Understanding the wider social context is crucial to smart solutions. Solutions should benefit as many people as possible, producing equitable investments in smart systems...
Nature is the perfect smart technology. Use it."

Doshik Yang, Director, The Center for Future City, K-water

SMART CITIES

Smart city principles are applied to the development of new towns, innovation cities, and the urban centers within free economic zones. Jaeyong Lee[3] described how the ROK originally used the term U-cities (ubiquitous cities) to describe smart city approaches, reflecting the ubiquitous integration of urban planning and service delivery that included:

- smart administration,
- smart infrastructure,
- smart transport,
- smart energy,
- smart economy and industry,
- smart health,
- smart safety,
- smart education, and
- smart welfare.

The key enabler for advancing to smart cities was the development of a high-speed national information network. As long ago as 2001, the ROK was identified by the Organisation for Economic Co-operation and Development as the country with the world's fastest information communication network.

Smart city development process in the ROK based on ICT progress

3 Director, Smart City Research Center, Korea Research Institute for Human Settlements.

The current National Smart Cities Strategy for the ROK proposes a flexible approach to implementation based on the growth stage of individual cities. Smart city development is realized through

- the creation of new national pilot cities,
- the expansion of existing smart cities, and
- urban regeneration through smart cities.

The Busan Smart City National Pilot Project is an example of the ongoing approach to smart city implementation. Dr. Doshik Yang presented the approach, dubbed an “eco delta city” because it works in harmony with nature to provide a livable environment for commerce, research and development, logistics, and residence.

Busan Eco Delta City includes the National Smart City Pilot Project. The area allocated is 2.2 square kilometers, and the design is intended to work with nature to capitalize on the hydrothermal cooling properties of natural water resources available locally. Core themes in planning and design include water and the environment energy, mobility, safety, and life and culture.

Sanjay Joshi, ADB, presented the Government of India’s Smart City Mission. The initiative has identified 100 smart cities nationally and allocated $30 billion for investment in 5,000 projects. The approach focuses mostly on existing cities and is demand-driven, developed in response to proposals from each city. The programs are implemented locally through a public special purpose vehicle. Proposals include urban regeneration, retrofitting basic infrastructure and services, and some pan-city projects such as implementing city wide integrated traffic-management systems.

4 School of Urban Sciences, University of Seoul.

Participants visited the Incheon Free Economic Zone. Established in 2003, it is expected to be completely developed by 2020, with a population of 500,000. Most of the zone is on reclaimed land, its three smart cities with one centralized operations center in Songdo. Songdo will become a deepwater port and hub for business and medical and biosciences. One smart city, Yeongjong, includes Incheon International Airport and will focus on logistics and tourism. Another, Cheongna, will specialize in finance, high-tech business, and research and development. As of December 2016, infrastructure expenditure had reached $35 billion, and employment 70,000. The free economic zone's strategic location and upfront investment in efficient and smart infrastructure has attracted about $10 million in foreign direct investment to date. The vision is to become the logistics hub of Northeast Asia.

SMART CITY MANAGEMENT AND OPERATIONS

Workshop participants visited the Incheon Free Economic Zone (IFEZ) and toured the smart city operations center in Songdo. Mr. Sang-Ho Lee, Director of the IFEZ Smart City Integrated Operation Center, outlined a smart city's three core elements: services, platform, and infrastructure.

Mr. Lee explained that a city evolves into a smart city when it adopts an information platform with the capacity to receive, process, and integrate data from infrastructure, the internet of things, and other public sources. A smart city platform can then send back system optimizations to improve infrastructure operations, efficiency, and the quality of services. In the IFEZ, the city has its own platform for a smart city operations center, in which city managers monitor and control the whole smart city network. The center also houses a public cloud data storage center.

An advanced traffic-management system is an ICT-based platform that integrates transport network information and performs real-time analysis to optimize transport infrastructure and provide information to users.

SMART TRANSPORT AND PUBLIC SAFETY

Nationally, the ROK has developed numerous ICT-enabled transport-management systems in response to a steep rise in vehicle numbers, by a factor of 16, in the 1980s and 1990s. These systems are operated locally by municipalities, but development support is provided by the Korea Transport Institute. Taehyung Kim[5] presented the concept for the Advanced Traffic Management System, as illustrated below.

Like the IFEZ, Anyang City established a centralized operations center in 2008. The center collects, analyzes, and provides traffic information by combining cutting-edge information technology with traffic system components. Ultimately, traffic flow is optimized to reduce congestion. Emergency services are notified to improve response times to traffic accidents, prevent secondary accidents, and minimize traffic congestion. Video recorded before and after the accident is stored and can be used for analysis to resolve disputes.

A unique feature of the system in Anyang is the monitoring of public spaces to enhance citizen safety. This is done through an integrated network of 6,000 publicly installed and operated closed circuit TV (CCTV) cameras.

5 Head, Division for Smart City and Transport, Korea Transport Institute

"A smart city integrates physical, digital, and human systems in the built environment to deliver a sustainable, prosperous, and inclusive future for its citizens."

Jaeyong Lee
Korea Research Institute for Human Settlements

Anyang is a satellite city of Seoul with 600,000 residents. It is the first city in the ROK to develop a customized application designed to connect individual smartphone users with the local government crime prevention center. Once the app is downloaded and activated, the user's location is sent to the command center, which periodically tracks the user's real-time location. The app also features an alarm activated by shaking the device.

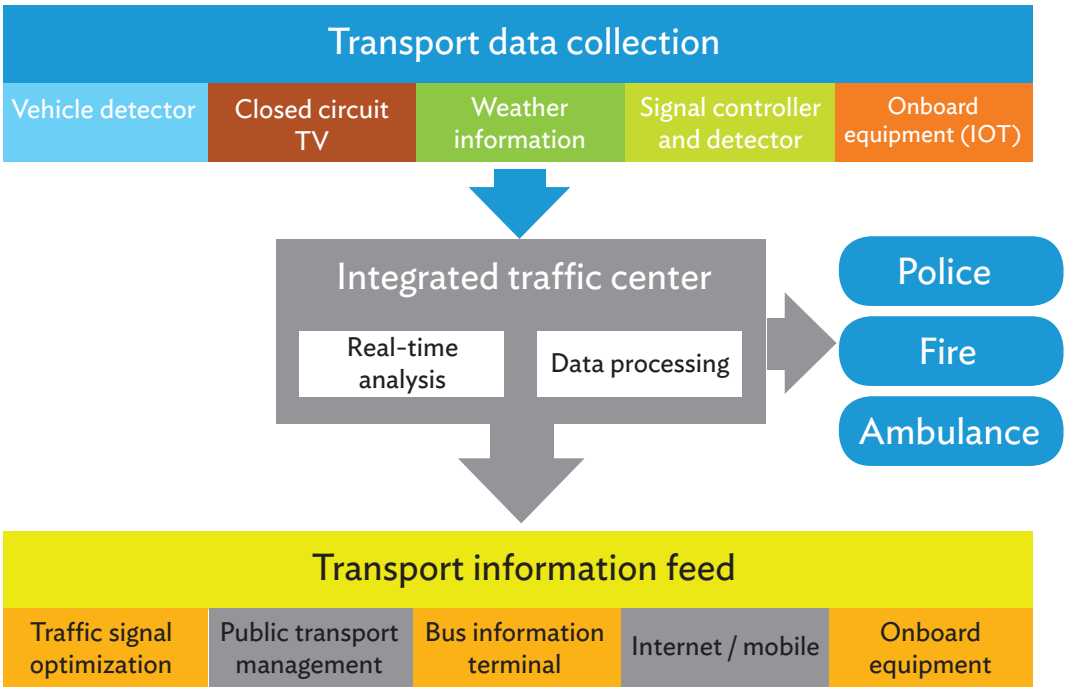
Mr. Joongkwon Oh[6] presented the T-Money smart card system. This public–private partnership for public transport payment integrates all public transport in Seoul, including taxis, under a pay-once system based on the distance traveled. The smart card system is an open platform that accepts all bank cards and allows private sector revenue generation, efficient public transport management, and government data acquisition. The technology is being expanded to other cities in the ROK and abroad.

6 Manager, Korea Smart Card Co. Ltd.

"I am particularly interested in the applications of smart cities in traffic control and improving citizen safety. In Delhi, we have some CCTV cameras, but we would not have the coverage that we can see here in the ROK. We need to integrate the management of city services, and we need this to support crime prevention.

We are applying smart city approaches in our GIFT City [Gujarat International Finance Tec-City], and the lessons we are learning here could also be applied there."

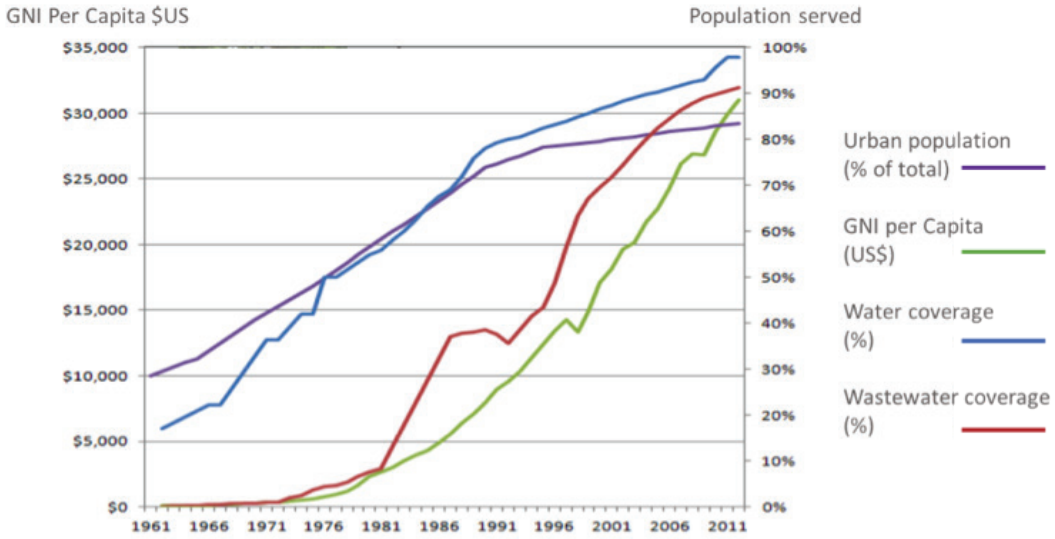
Reema Jain
Deputy Director, Atal Mission for Rejuvenation and Urban Transformation, Ministry of Housing and Urban Affairs, India



SMART WATER SUPPLY

Rapid population growth and urbanization after the Korean War increased the recorded incidence of E. coli contamination in the ROK by a factor of 150 from 1963 to 1967. Since then, and within a relatively short period time, the country has made remarkable progress in the water sector. The figure below illustrates the rapid development of water-supply and wastewater infrastructure in the ROK, from serving less than 20% of the population in the 1950s to 100% coverage today. Heavy investment in water infrastructure was enabled by economic growth and loans from international financing institutions.

As well as heavy public investment in infrastructure, the ROK has developed globally recognized research institutes, such as KEITI and K-water, responsible for generating innovation in smart water management technologies and producing high-quality water professionals.



The figure shows the development of water-supply and wastewater infrastructure in the ROK since the 1950s. Note the lag between water-supply and wastewater infrastructure provision, and also the gross national income per capita growth rate in the same period.

Policy focus in ROK water supply development

1960s	1990s	2000s	2010s
Invest in capacity	Improve qualtiy	Improve efficiency	Smart systems

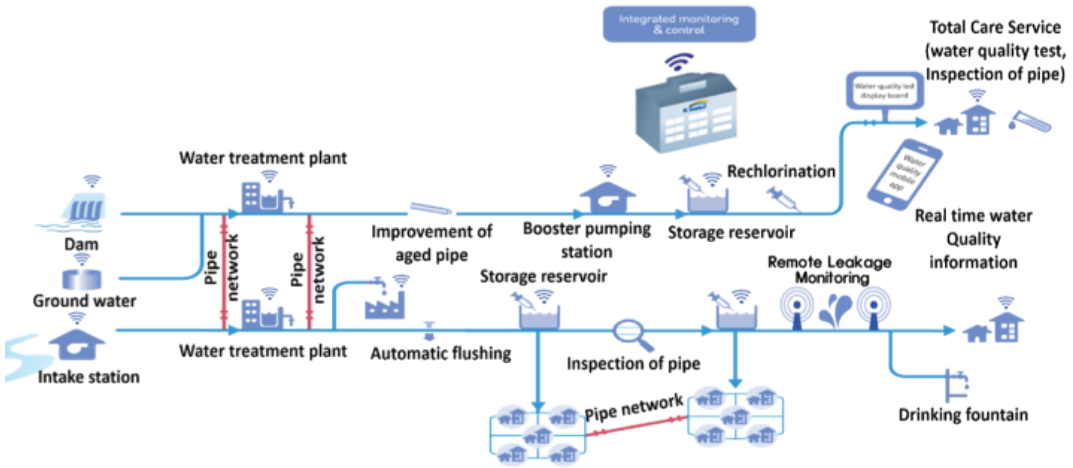
Smart water supply systems embody innovative technologies that can be applied across all aspects of integrated water resource management, including:

- managing environmental water,
- forecasting and the operational management of water resource facilities for improved flood and drought control,
- integrated energy production at dam sites,
- bulk water supply,
- the treatment of drinking water,
- water distribution, leakage reduction, and nonrevenue water reduction, and
- billing and collections.

"K-water has vast experience in managing water resources and introducing innovations into water management. We are happy to exchange our experiences and share our expertise regarding smart water and wastewater management. We hope you learn from our expertise, and we hope you can apply them in your country."

Mr. Doosoo Park
Vice President, Korea Water Resources Corporation

Introducing smart technology—including data collection, communication, and automation—to these systems enables better decision making and faster response, which improve the operation of water systems.



K-water's integrated water resource management centers compile and display real-time information and climate predictions from across their networks. These data drive automated operational responses, removing human decision-making from operational processes such as reservoir water level management, hydropower generation, and pumping station operations.

Participants visited K-water's regional Hangang Water Supply Operations Center, which manages continuous supply of bulk water to municipalities home to 55% of the population of the ROK, including the Seoul metropolitan area and other municipalities. The regional center remotely manages the operation of 13 dams and reservoirs and 5 regional water-supply facilities. Real-time weather data and predictions are integrated into automated operational decision-making to manage storage in the water system, to ensure drought and flood resilience and optimize energy production at hydropower sites.

Participants also visited K-water's national operations center in Daejeon, which oversees water resource management at a national level with a particular focus on data management and analysis. The center houses the:

- water data planning team,
- water data integration team,
- National Drought Information Analysis Center, and
- National Groundwater Information Center.

Data are stored, integrated, and analyzed for standardization and quality control, public accessibility, and enhancement of integrated water resource management.

The national center at Daejeon also houses the national water quality research center and laboratory, whose ambition is to become the best water lab in the world. The purpose of the facility is to ensure the safety of drinking water and improve public trust in drinking water quality. The lab has capability to test for over 500 water quality parameters, physical, organic, inorganic, and microbial. Research and development at the center covers the prevention of nonpoint source pollution, algae control, remote sensing for water quality monitoring, and enteric virus prevention.

Participants visited the Daecheong Dam, which is a concrete and rock-fill multipurpose dam for water supply, flood control, and power generation. It is 84 meters high, has a storage capacity of 1.5 billion m3, and a power generation capacity of 90,000 kilowatts—enough to power 40,000 households. The spillway is designed to safely discharge 20,000 m3/second.

"In Bhutan we have some good expertise in planning, but we will require support from donors and other international institutions as we continue to develop. We need support in the application and operation of new technology, in water supply for example. We also need to train our workforce or contractors to build quality infrastructure."

Jigme Dorji, Project Manager Dept. Engineering, Ministry of Works, Bhutan

NONREVENUE WATER MANAGEMENT

The ROK has aging water-distribution infrastructure. More than 30% of pipes in the ROK are over 20 years old, prompting the commencement in 2005 of a country-wide nonrevenue water (NRW) program. Nationally, NRW was reduced from 21% in 2005 to 16% in 2015. This was achieved through a number of smart approaches, including improved design, monitoring, management, and operation of water-distribution networks. The approaches are underpinned by establishing in distribution networks district metered areas (DMAs).

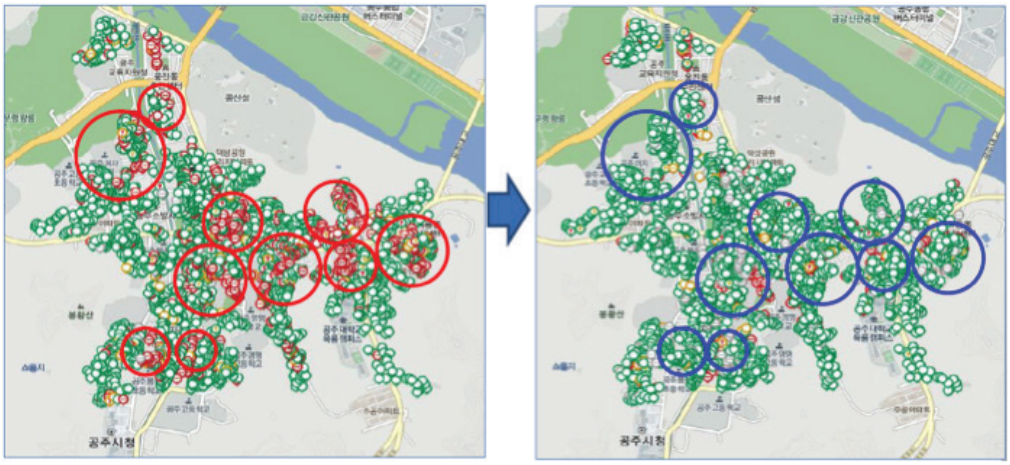
DMAs are simply blocks within the water distribution network established by hydraulic isolation, with water meters monitoring flows in and customer meters monitoring flows out. A simple water balance can then be calculated and used to understand leakage and other losses within each DMA. With DMAs across a whole water-supply network, utilities or operators can identify high-loss areas and then target pipe replacement or repair, as well as leakage and pressure management projects, to reduce NRW.

Smart meters are installed like conventional water meters but can monitor and report flow and pressure remotely through wireless communication technology. Their installation allows real-time centralized monitoring and management of the DMA water balance to identify and repair pipe bursts and leaks as soon as possible.

Mr. Kwansuhk Oh[7] presented at the workshop an innovative solution that installs acoustic monitoring devices to listen for leakage at night. The monitoring devices are georeferenced and communicate directly with a central system to map leakage areas, to which teams can be deployed to repair or replace damaged pipe. The case study illustrates that NRW can be reduced rapidly by applying DMA-based smart leakage detection solutions, quickly returning savings greater than the investment. Once the infrastructure is in place, leakage can be kept low at little cost.

7 Director, Total U-city Solutions.

Gongju City in the ROK invested $2 million from 2014 to 2017, with the support of Total U-city Solutions, in 7,000 leak sensors to identify and repair leaks in the water supply system. Since 2014, NRW has fallen from 36% to 15%. This water saving brought cost savings of $3 million. The graphic (right) illustrates the georeferenced location of leakage sensors, the change in color from red to green occurring where leakage problems have been resolved.



In Bangladesh, Dhaka Water Supply and Sewerage Authority (DWASA) has been phasing in smart water systems since 2008, including billing by text message and internet payment. The authority separated Dhaka's water supply system into 10 zones and 145 DMAs. This reduced NRW from 40% to 20% in 10 years, as presented in the table below.

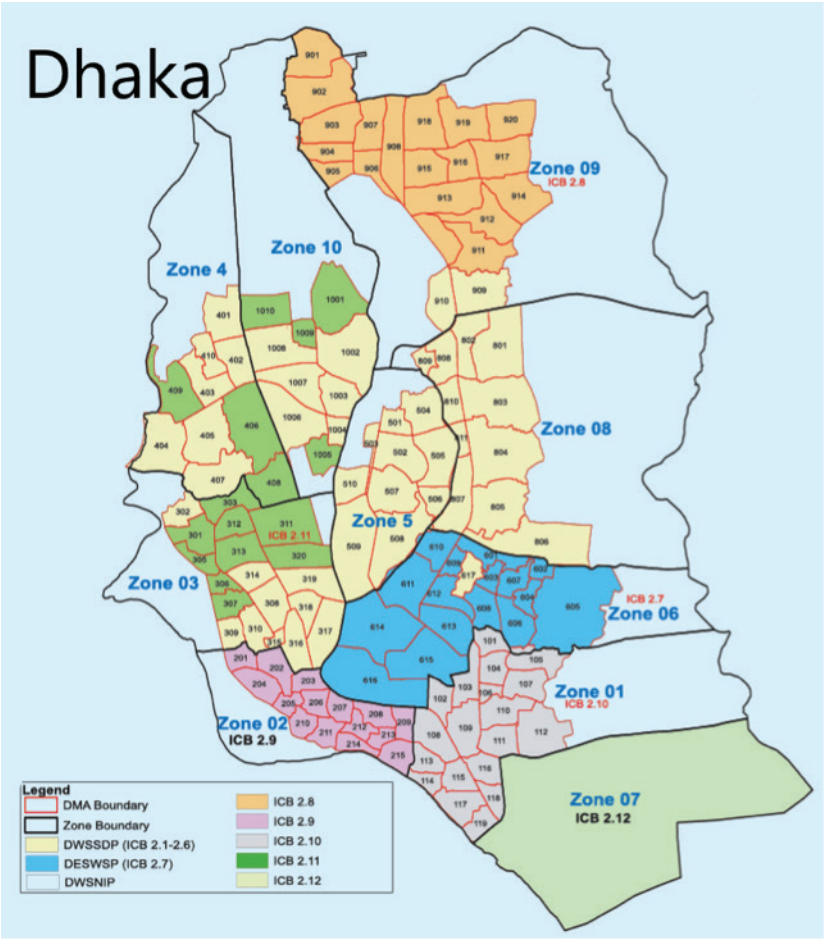
	2008	Target	2018
Total NRW (%)	40	25	20
NRW in DMAs (%)	na	15	5
Bill collection (%)	65	95	97
Manpower per 1,000 connections	16	12	9

district metered area, na = not applicable, NRW = nonrevenue water.

Mr. Mahmudhal Islam, Project Director, DWASA, presented DWASA achievements to date in implementing their smart water projects.

Dhaka still faces significant challenges to delivering safe water to its residents. The population of Dhaka is expected to be 29 million by 2035. Significant investment in water treatment is required in the next few years as the water supply goal is to increase the supply of drinking water from surface sources from the current 22% to 70% by 2021 in response to groundwater depletion and quality issues.

Further, DWASA is planning a widespread program to install customer smart meters with real-time billing and an integrated operations system with supervisory control and data acquisition.



DWASA divided Dhaka into 10 water supply zones and 145 district metered areas.

PACKAGE TREATMENT PLANTS

Small-scale treatment plants are practical in rural settings where treated water needs to be distributed over large areas. The cost of treated water losses and system maintenance in such large distribution networks makes it economically viable to have smaller dispersed treatment plants located close to population centers. Such system are also practical in conflict zones and after natural disasters.

O2&B Environmental Engineering has developed a multipurpose mobile water-treatment plant that includes micro-, ultra-, and nano-filtration and reverse osmosis modules that are interchangeable as demanded by circumstances and for easy maintenance. An inbuilt computer control module allows centralized remote operation of numerous plants. It is simple to transport and install, taking up little space. A complete treatment system, including all modules, can be installed to mitigate the need for water quality testing and analysis before installation.

Workshop participants were introduced to GJ-R, a package system developed and exported by Gyeongju Municipality that uses innovative coagulation and low-energy micro-bubble flotation technology. The system can be containerized for 100 m^3/day or constructed in situ for 1,000–2,000m^3/day systems. The technology can be applied on larger scales but these require reinforced concrete installations.

WORKSHOP Q&A: SMART WATER

In Asia, where we have limited resources, where should we start?

Quantity is the first place to start. Metering is key! If we do not understand our system and losses, where do we start? Further, it depends on the conditions in the city. For example, in Seoul, we use cheap energy at night to pump to reservoirs. That is smart.

How does Dhaka recover the cost of investment?

We have an expensive program to replace all pipes with high-density polyethylene pipe. The cost seemed prohibitive, so we undertook financial analysis and increased our tariff from 7 taka per cubic meter to 10 taka. If we improve the service, we can raise tariffs without objections. We have also improved billing systems and collections, significantly reducing losses. These actions increase revenue and reduce costs.

In Bangladesh, we have issues with water source depletion, so we are considering rainwater harvesting and seawater desalination. Is there any plan in the ROK for rain and seawater?

K-water has no rainwater projects. Seoul is encouraging residents to use rainwater, subsidizing 90% of the cost of tanks. But water is cheap, at half a US dollar per cubic meter, so users have little incentive. We have desalination plants with capacity of some 100 cubic meters per day. These are located in areas with high industrial water use far from suitable freshwater sources, which makes desalination viable.

In India, 27 million people are affected by arsenic and fluoride. Is the O2&B package plant affordable for small communities of 10,000–20,000 people with water billed at 20 US cents per cubic meter?

The plant can remove 99% of fluoride. It uses only 1.2 volts so can be powered with solar panels. The capital cost of the system is $50,000–$100,000, but it has low maintenance cost and is scalable. It would be applicable in small settlements with fluoride issues such as in West Bengal and Rajasthan.

We have high iron content in our system. Iron precipitates in meters, requiring replacement that is unaffordable. Are there smart meters that can help with this issue?

No, you need to reduce or blend out the iron.

How do you achieve cost recovery when implementing smart water management systems?

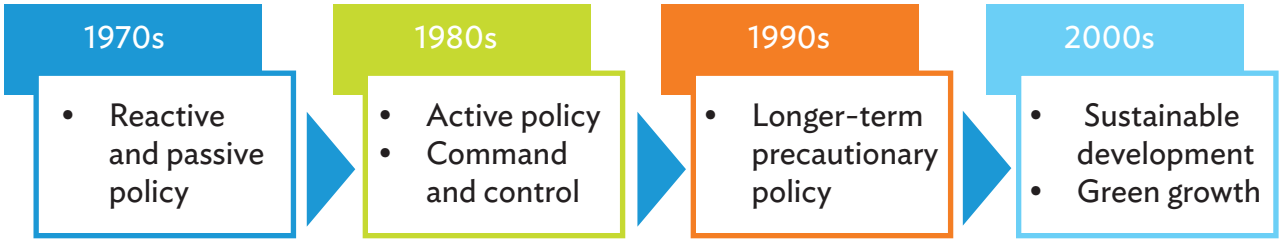
In the ROK we use smart water management to reduce labor costs, and to reduce water losses, which lowers cost. Often, systems in the ROK have payback periods of 2–5 years, but we are a developed country, where policy can drive technology development and the government has the capacity to subsidize infrastructure improvements.

SMART WASTEWATER MANAGEMENT

Within a relatively short period of time, the ROK has made remarkable progress in the wastewater sector. According to Mr. Eun Namkung, the first wastewater treatment plant was constructed only in 1976; by 2016, the ROK had 625 treatment plants, and 93% of all wastewater was collected and treated to a very high standard before being discharged into the environment. The heavy investment in wastewater infrastructure was enabled by economic growth and loans from international financing institutions.

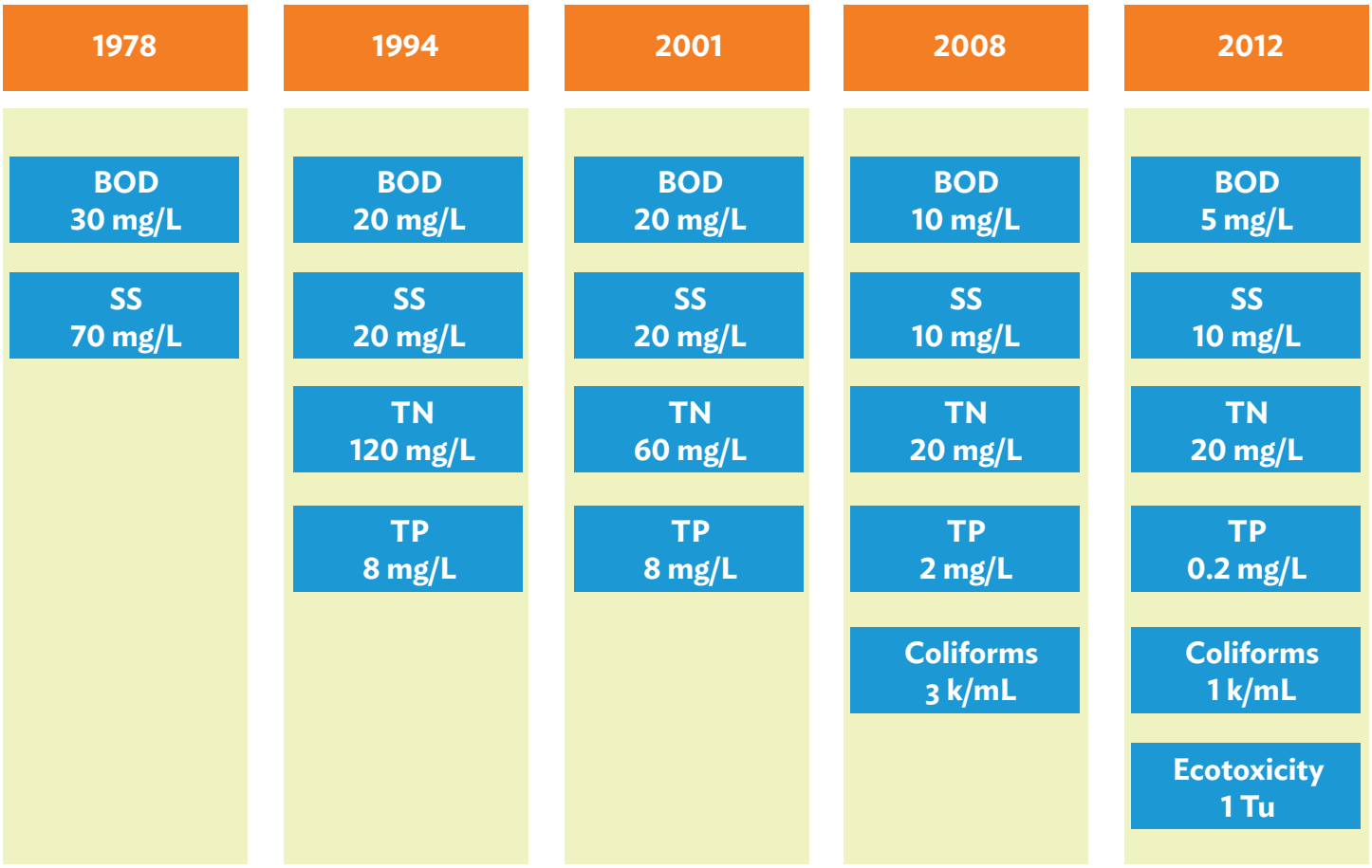
WASTEWATER POLICY

The improvements in wastewater management were not brought about by investment alone. Better environmental policy, regulation, and enforcement have all been key drivers. The current environmental policy focus is on sustainable development and green growth, as illustrated in the policy development diagram below.



To meet these policy developments, the ROK has enacted laws with progressively stricter standards for wastewater treatment plant effluent, as shown below. This has enabled the development of technology able to respond to stricter standards.

8 President, Korean Academy of Environmental Sciences, and professor, Seoul National University.



BOD = biochemical demand, mg/L = milligrams per liter, SS = suspended solids, TN = total nitrogen, TP = total phosphorous, TU = toxic unit.

Effluent treatment standards in the ROK have progressively tightened under a number of environmental laws enacted since 1978a. Currently, wastewater treatment plant effluent is monitored against six parameters including biochemical oxygen demand, suspended solids, total nitrogen, total phosphorous, coliform count, and ecotoxicity.

High standards of wastewater treatment in the ROK and the technology employed make wastewater services expensive and undervalued socially and politically.[9] This means that central and local governments shoulder most of the service cost, with the sewerage service charge covering only about 45% of the total cost.

This government support to policy development and subsidy illustrates that the economic benefit of wastewater management is valued and ultimately allows water managers to consider wastewater as a resource, enhancing integrated water resource management.

9 Undervalued by local governments, which are responsible for setting tariffs

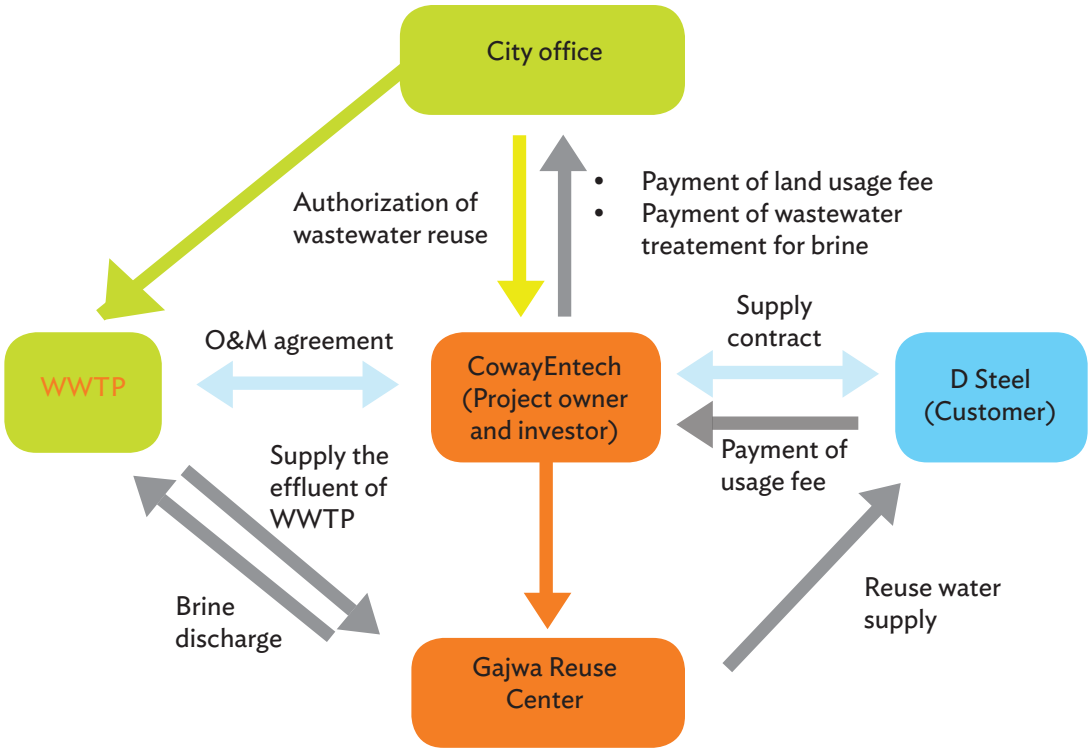
WASTEWATER REUSE

Mr. Jeong On Kim[10] presented an example of wastewater reuse that has become commercially viable in Seoul thanks to the high cost of potable water. Coway Entech supplies treated wastewater effluent to two industrial facilities under 15- and 20-year contracts: 7,500 m^3/day to the Gajwa Reuse Plant and 22,000 m^3/day to the Pocheon Reuse Plant.

Under these projects, Coway Entech has invested in advanced filtration plants that deliver high-quality feed water to industrial customers near wastewater treatment plants. Each partner benefits from the project:

- The city government benefits from reduced demand on water resources and will inherit an asset after the 15-year operating period.
- Customers obtain water better than tap quality at a lower price.
- The project developer profits financially and advances its technologies.

Coway Entech operates a wastewater reuse treatment plant under a 15-year build-own-operate-transfer agreement with the Seoul City Office. It has an effluent supply agreement upstream with the local wastewater treatment plant and a contract to supply cooling water downstream to a local steel manufacturer. The plant is located on city-owned land and utilizes ultra-filtration and reverse osmosis to deliver high-quality treated water from wastewater treatment plant effluent.



O&M = operation and maintenance
WWTP = wastewater treatment plant.

10 Coway Entech.

Ms. Neeta Pokhrel shared an experience in wastewater management in Kolkata. Through ADB support, the Kolkata Municipal Corporation recently installed India's first comprehensive city-level flood forecasting and early warning system. It uses ultrasonic sensors that send real-time geographic data to a cloud-based system for analysis. Through two ADB-supported projects, the Kolkata Environmental Improvement Project and the Kolkata Environmental Improvement Investment Program, Kolkata Municipal Corporation is systematically expanding the sewer and drainage network in Kolkata, increasing sewage treatment capacity, reducing non-revenue water, managing solid waste, and building their capacity to sustain services.

INNOVATION

As noted by Eun Namkung, the priority areas for innovation in the ROK are further advances in efficiency, the development of more advanced technologies for wastewater treatment, advances in wastewater and energy recovery, safety, and odor control.

Participants visited KEITI's Environmental Industry Research Complex. The site is an incubator for environmental technology development with a particular focus on water and wastewater treatment. It is a turnkey facility that includes onsite laboratories, test beds, water and wastewater supply, prototyping facilities that use 3-D printing, administrative support, conference rooms, and accommodation.

WORKSHOP Q&A: SMART WASTEWATER

What is driving improved wastewater treatment in the ROK, government or social pressure? Or is it just a result of economic development?

It is a result of all of these drivers. In particular it is a response to the obvious environmental degradation that resulted from rapid economic development. There were some serious pollution events in the ROK in the 1990s.

On tariffs, does the ROK subsidize wastewater management?

Yes, currently our water tariff is approximately 80% of our production cost, which is $1 per cubic meter, and our wastewater tariff is approximately 45% of our cost, again $1 per cubic meter.

We are raising tariffs year on year, but it is done by local governments and highly politicized. By 2025, we hope to cover 100% of cost with the tariff.

How do you meet the high standards that you set in the ROK?

The government cannot afford all the necessary investment at one time, so treatment can be added in phases. We start with organics, then deal with eutrophication caused by nitrogen and phosphorous, and finally toxic materials. Each process adds to cost and energy needs.

What is the cost of wastewater reuse using ultra-filtration or reverse osmosis?

In the ROK, it is generally 1.5 times the cost of conventional treatment. However, the value of potable water is significantly higher. The ROK has a number of industries that require ultra-filtrated water, notably manufacturers of electronic components for smartphones. In Incheon, tap water is very expensive at $2 per cubic meter, as water is scarce. This makes wastewater reuse commercially viable.

In areas with low flows in the dry season, we maintain very high treatment standards to sustain adequate flows in streams. This is a form of water reuse to support natural environments.

Do you have water conservation programs?

The best way is through pricing. You reduce consumption through a volumetric tariff. Some smart cities have introduced volumetric tariffs and now have very low consumption.

The ROK has done a great job of managing water demand. Fifteen years ago, daily consumption was 400 liters per capita per day. Now it is 284. This was done through pricing and leakage control, as well as through education programs from a very early age. Our goal is to reduce consumption to 200 liters per capita per day by 2025.

SMART WASTE MANAGEMENT

Workshop participants were led on a Sudokwon Landfill site visit by Mr. Heedong Kwon.[11] The Sudokwon Landfill, which services the Seoul metropolitan area and its 25 million people, is on reclaimed land approximately 35 kilometers west of Seoul. The landfill site is jointly owned by the ROK Ministry of Environment and Seoul city government and is operated by a state-owned enterprise, SL Corp. It is the largest landfill site in the world, with an area of 20 square kilometers and a height of over 100 meters. It is also one of the world's most advanced landfills and a marvelous example of integrated resource recovery and sustainable waste management.

As well as a state-of-the-art sanitary landfill, the Sudokwon site houses a 6,700 ton/day leachate treatment system, 200 ton/day solid recovered fuel plant, 200 ton/day sludge recovery plant, and 500 ton/day food waste effluent biogas plant.

The landfill includes six 50-megawatt landfill gas electricity generators. Collectively, it is the world's largest landfill gas power plant, providing electricity worth $30 million annually for 43,000 residents. It is registered as a Clean Development Mechanism project with certified emission reduction equal to 900,000 tons of carbon dioxide.

To address residents' opposition to the landfill site in their neighborhood, developers transformed the landfill into an environmental, cultural, and leisure attraction that includes a wildflower garden and a golf course with subsidized fees.

11 Senior Manager, SL Corp.

Significant advances in integrated urban solid waste management in the ROK have allowed a 95% reduction in waste sent to landfills since 1990. This has been achieved through waste segregation and minimization (including the introduction of a pay-per-volume mechanism for households), recycling and resource recovery, and incineration. The landfill itself is now primarily used to dispose of some hazardous wastes and to manage waste during peaks, when waste generation exceeds incineration capacity.

Interventions in solid waste management in ADB projects were discussed by participating officials from Nepal and Maldives.

Workshop participants visited Hanam City's Union Park underground waste-management facility, which integrates a materials recovery and recycling center, waste-to-energy incinerator, food waste-to-animal feed plant, wastewater-treatment plant, and sludge-treatment facility. To allay local residents' concerns over the siting of the facility, it is constructed completely underground and equipped with a sophisticated odor-management system. Communal amenities have been provided for free use by local residents, including a park, a gym, and sports facilities.

"In Sri Lanka we need to apply some of the lessons learned in best practices for landfill design and operation. In 2017 we had a landslide at our dumpsite in Colombo."

Tshuhari Kariyawasam
Deputy Director, Urban Development Authority, Colombo

Mohamed Hamdhan, Maldives Ministry of Energy and Environment, presented to the workshop the Thilafushi Island Dumpsite, pictured left, which is to be transformed into an integrated waste-management facility. With ADB support under the Greater Malé Environmental Improvement and Waste Management Project, the current landfill site will be safely sealed and restored, and community-based outer island waste management systems will be introduced. A subsequent project, financed by multiple development partners and currently in planning stages, will see the development of a new waste-processing and sanitary landfill site with a 6 megawatt waste-to-energy incinerator under a design-build-operate contract.

In Nepal, towns are leveraging private sector participation to implement integrated solid waste management at the grassroots level through three ADB projects. This includes the development of landfill sites and adoption of recycling processes. In Pokhara, for instance, a road made from recycled plastic has been built by the private sector. In Kirtipur, the private sector is operating a large biogas plant. In Hetauda, a composting facility has been developed. In Kathmandu, private firms collect half of all waste collected from households.

WORKSHOP Q&A: SMART WASTE MANAGEMENT

How is your Maldives project climate resilient?

Maldives is very low-lying. We have designed the infrastructure to be resilient under climate change over its design life. We reduce the need for waste transport by providing a waste-sorting and transfer station at each outer island. We will generate energy from the incinerator. Both of these design features reduce the carbon emissions required to manage waste, which helps combat global warming.

Reducing waste must be important in the Maldives because of the limited land available to manage waste. How do you do this in Malé? Also, how do you include gender objectives in the project?

To date there are no fees for collection, which means people do not understand the cost of managing waste. We have recently introduced a fee to address this, but it is not easy to implement. We are now educating households on waste management and its importance and cost.
In Maldives, women are usually in charge of waste management in their households, so it is absolutely necessary to consider the impact of the project on women, as well as to incorporate women's views into project design.

In Nepal, we have struggled to implement projects because of local social and political issues. What social problems do you face in developing projects in the ROK?

We reclaimed our landfill site, so we did not face land-acquisition issues. We had to do significant work on the environmental impact assessment. We still have a NIMBY problem because local residents never want a landfill in the neighborhood. To resolve it, we include community programs in landfill project design.

In the ROK, how do you segregate organic and inorganic waste?

We separate them at the household level, imposing fines for noncompliance.

Landfill and incineration pose challenges and may not always be environmentally sustainable. Will there be better solutions in the future? In the ROK, what is the current research focus?

We are not currently developing any new approaches but are developing new technology to make landfill and incineration more efficient and less harmful on the environment. We can also generate energy, which is an additional benefit. We are currently piloting a program to recycle leachate to generate more methane and reduce the environmental impact. This will not be a magic bullet, but it will generate small improvements in efficiency and management across the whole waste stream.

"As Maldives is a nation of coral atolls, our water resource situation is different to the situation here in the ROK. Our focus at this workshop is to learn from ROK best practice in solid waste management, particularly incineration technologies. We are implementing a waste-to-energy project at home in Maldives."

Mr. Mohamed Hamdhan
Greater Malé Environmental Improvement & Waste Management Project

Mr. Hun Kim, Director General,
South Asia Regional Department,
Asian Development Bank (ADB)

"This year ADB will lend about $22 billion to its developing member countries. South Asia has become the biggest and fastest growing of our five regions, with a total lending of $7 billion. South Asia has 1.5 billion people and a $3 trillion economy, which continues to expand at around 8% annually. Transport is the number one sector for ADB lending, with a new focus on large urban public transport projects.

"ADB is not just a financier. We also provide grants for technical assistance. Through these, we wish to improve governance and skills and bring new technologies to the market. ADB can also facilitate partnerships between suppliers and potential customers, as well as between investors and project developers. In this way, ADB hopes to accelerate normal market processes.

"Several cities in South Asia have already benefitted from technical expertise sent by urban entities in the ROK. This is very encouraging, and we wish for this to continue.

"This workshop reflects deepening cooperation between the ROK and ADB. The ROK has much to offer as a newly developed country. It can share recent experiences and innovations made recently in a period of very fast growth, as well as lessons learned in managing rapid urban growth and maintaining environmentally sustainable infrastructure."

Mr. Changheum Lee, Director General
of Environmental Industry & Technology
Department, ROK Ministry of Environment

"We are faced with a daunting challenge of pursuing sustainable development to maintain urban and environmental systems for the next generation. This workshop is a valuable opportunity to push the boundaries of business as usual. Together, Asia can rise to this challenge.

"The ROK has faced numerous environmental problems in the past, which have undermined living conditions. The government has invested in developing technology to find smart solutions in the urban sector. This has been underpinned by strong and forward-thinking policy.

"The world now holds the ROK in high regard as a model for maximizing the balance between environmental protection and economic growth.

"I hope delegates from each country facing environmental issues will learn from seeing first-hand the solutions that have been developed by the public and private sectors in the ROK toward resolving the challenging environmental issues that result from rapid urban growth."