Knowledge Sharing Program

2016/17 KSP-IDB Joint Consulting Project :

Technology Transfer for Water and Wastewater Treatment Industry in Colombia

Korea Eximbank
THE EXPORT-IMPORT BANK OF KOREA

Ministry of Strategy and Finance

IDB
Inter-American Development Bank

2016/17 KSP-IDB Joint Consulting Project

Project Title	Technology Transfer for Water and Wastewater Treatment Industry in Colombia
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Financed by	Ministry of Strategy and Finance, Republic of Korea
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ACODAL	Colombian Association of Sanitary and Environmental Engineering (Asociación Colombiana de Ingeniería Sanitaria y Ambiental)
CAR	Regional Environmental Agency (Corporacion Autonoma Regional)
CONPES	National Council of Economic and Social Policies Consejo Nacional de Política Económica y Social)
DNP	Department of National Planning (Departamento Nacional de Planeación)
EDCF	Economic Developement Cooperation Fund
GWI	Global Water Intelligence
IDB	Inter-American Development Bank
IIC	Inter-American Investment Corporation
IWA	International Water Association
KEITI	Korea Environmental Industry Technology Institute
KOICA	Korea International Cooperation Agency
LID	Low Impact Development
MADS	Ministry of Environment and Sustainable Development (Ministerio de Ambiente y Desarrollo Sostenible)
MPS	Ministry of Health and Social Welfare (Ministerio de la Salud y Protección Social)
MRO	Minimum Revenue Guarantee
MVCT	Ministry of Housing, City and Territory (Ministerio de Ambiente, Vivienda y Desarrollo Territorial)
NGO	Non Govermental Organization
ODA	Official Development Assistance
O&M	Operation and Maintenance
PDA	Aqua Development Plan
PND	National Development Plan
PNGIRH	Política Nacional de Gestión Integral de recursos hídricos
PPP	Public Private Partnership
R/O	Reverse-Osmosis
SOC	Social Overhead Capital
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Program

VASE	Vice-Ministry of water and sanitation
VASE	(Viceministerio de Agua y Saneamiento Básico)
WHO	World Health Organization
WWT	Waste Water Treatment
WWWT	Water & Wastewater Treatment

Summary

The goals of the work reported in this paper were to contribute to the expansion of water treatment infrastructure and efficient management of treatment plants in Colombia, to develop related industrial capacity, and to provide opportunities for local water treatment companies to enhance their sustainable technology. To support these goals, it was necessary to analyze the current water treatment conditions in Colombia; to compare them with the water treatment related policies, industry, and PPP cases in South Korea; to select appropriate technology that fits the situation in Colombia; and to establish plans to transfer the technology.

There is a significant gap between urban and rural regions in the quality of Colombia's water distribution and sewage treatment systems. Moreover, 45% of the water supplied is lost to leakage due to deterioration and inappropriate management of the waterworks system. The sewerage distribution rate announced by the Colombian government, calculated from the distribution of pipes, is at 20%, which is the actual sewerage treatment rate. The processing method most used is the lagoon method, which is 1^{st} - 2^{nd} generation water treatment. However, fundamental solutions to the water-treatment-related issues Colombia faces are not available due to the low level of technology available to Colombian water treatment companies.

The water management system of the Colombian government is in the form of a diversified structure, with MVCT in charge of the water quantity and MPS in charge of the water quality, indicating a possible need for a department dedicated to the general management of water. The quality of drinking water and water discharged after treatment is managed to a lower standard than those of Korea; therefore, transferring Korea's technical and management know-how could contribute to maintaining safer and cleaner water.

There are nearly no manufacturers in Colombia who can provide the tools and materials related to water treatment. For this reason, the domestic capacity is extremely low, and most such supplies and materials are imported from foreign countries. There are regional companies who could provide water treatment management services, but which suffer from low efficiency due to the lack of management know-how and R&D. Such problems stem from a shortage

of professionals (regarding management of water treatment) and from the financial burden of high management and maintenance costs. When transferring technology, the most appropriate ones will be those that support the water quality standards of Colombia, that are consistent with the local situation, that involve technology that can easily be transferred, and for which adequate training is easy. It would be also important to use energy-efficient tools and materials, and to introduce technologies able to provide lower management cost and greater sustainability.

In order to establish the most appropriate technology transfer plans for Colombia, an accurate diagnosis of the local situation and the technical demands was performed using the local networks. Columbian government officials in the field of water treatment policy were invited to Seoul to share Korean experience with water treatment policies and to visit major water treatment facilities that utilize PPP (public-private partnerships). Also, a technical cooperation channel was established between the two countries by introducing Columbian officials to Korean manufacturers of water treatment technologies. Through the technology introduction session and the meetings with individuals of technology companies in the local final report session, a foundation was provided for the actual technical exchange and transfer between the companies and Columbian officials in the future.

There are companies able to provide water treatment management services in each region, but these suffer from low efficiency due to the lack of management know-how and R&D. This mainly stems from the high burden of costs for management and maintenance, caused by a shortage of professionals in water treatment management and high energy costs. When transferring technology, the best ones would be those that are consistent with the water quality standards of Colombia, that fit the local conditions, that are easily transferred, and for which training is easy. It would be also important to use energy-efficient tools and materials, and to introduce technologies that provide low management cost and greater sustainability.

The models of technology transfer can be classified as joint ventures between companies, public-private partnerships (PPP) with cooperation between the private and public sectors, EDCF or ODA projects, and the establishment of a central organization for technical cooperation. In certain parts of technology transfer through the establishment of a central organization for technical cooperation, connection with Korean EDCF or ODA projects can be required.

There is a need to provide water treatment technologies and various global cooperation models adequate for the conditions in Colombia, to provide sustained support for technical cooperation programs tailored to the recipient country, rather than simply transferring patented technologies. For the difficulties faced by Colombians in terms of water treatment management

technologies, a long-term cooperation model such as transferring know-how or establishing joint ventures seems to be more appropriate than simple transfer of technologies. Based on the established technical cooperation channel established between the two countries, we expect technology transfer follow-up projects in the future will contribute to continuous cooperation and mutual development.

Ⅰ. Introduction

1. Background and Purposes

1.1 Background

Colombia provides a low rate of sewage distribution and treatment, and inadequate drinking water infrastructure, which result in flood damage and drinking water contamination. Not only are these problems causing damage to human life and properties, but they even threaten the 'quality of life' of the citizens. However, due to the low technical capability of Colombian water treatment companies, the fundamental challenges facing the water treatment industry there cannot be solved.

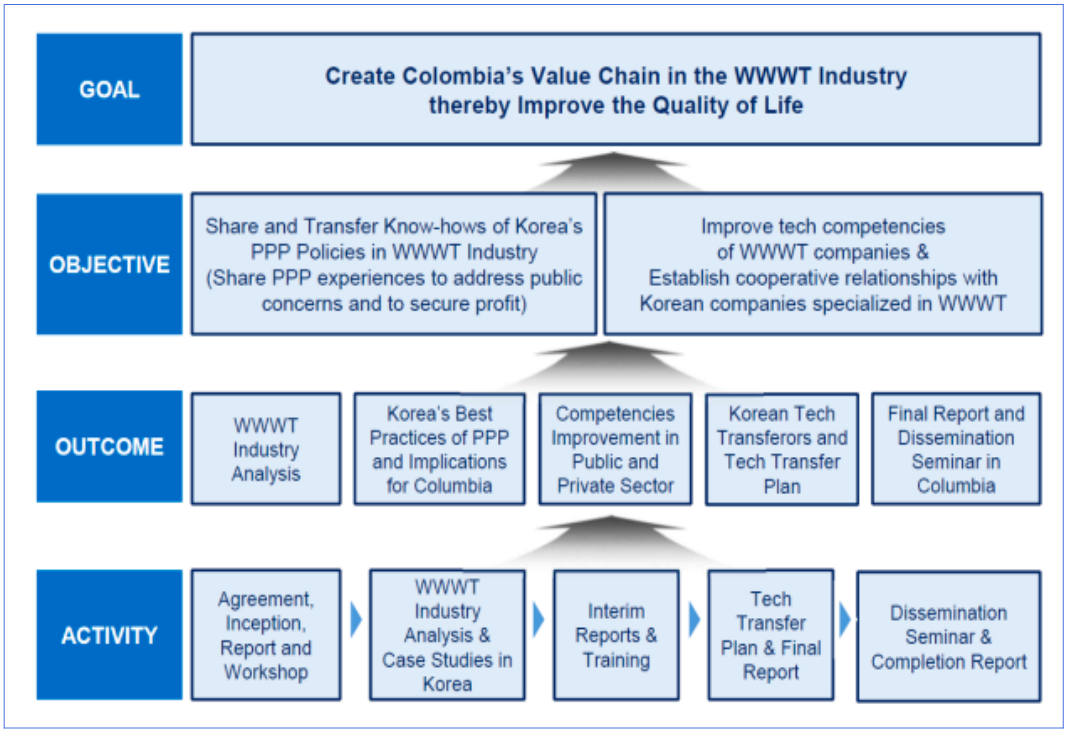
A recent trend is that the government aims to create synergy through co-operative projects with the private sector, as customer demands have become more sophisticated, water treatment technologies and infrastructure have grown more complex, investments have become huge in scale, and governmental organizations have inadequate technology and management know-how. The Colombian government currently faces a critical lack of investments due to the recent decline in oil prices, and thus is in great need of PPP (public-private partnership)-based expansion plans for its water treatment infrastructure.

Therefore, the IIC (Inter-American Investment Corporation) and the Korean Ministry of Strategies and Finance (MOSF) launched a project to establish plans for effective technology transfer in order to share Korean know-how to spur the development of the Columbian water treatment infrastructure and to enhance the technical competencies of Colombian water treatment companies.

1.2. Purposes

For the reasons stated, the Colombian government faces a critical lack of investments and thus is in great need of PPP-based plans to provide the required expansion and upgrading of its critical water treatment infrastructure.

Figure 1 | Project implementation plan and expected outcomes



2. Range and Expected Outcomes

2.1. Range

The range of this project is limited to the sewage treatment related industries in the water industry, and includes the management technology focused on public institutions and the manufacturing technology focused on private companies. The major content of this report include current condition analysis, studies of successful cases in Korea, establishment of plans for technology transfer, and actual execution of transfers to vitalize PPP in the field of wastewater treatment in Colombia.

2.2. Expected Outcomes

Provide opportunities for local water treatment companies to improve sustainable technology capacity by establishing technology transfer and technical cooperation channels with outstanding domestic companies that meet the needs of the local water treatment industry in Colombia. In addition, share the successful partnership establishment of public-private system in the water treatment field in Korea and effectively share precedent of law and institution. Provide training for policy working group in the field of water treatment for legal and institutional improvement of public-private partnership in Colombia and establish a foundation for sustainable development in the water treatment field.

The Inter-American Investment Corporation (IIC) will be conducting the actual transfer of water treatment technologies by supporting the technical cooperation project based on the technology transfer plan suggested in this consultation. By utilizing a follow-up project by the IIC, the Korean domestic water industry can establish the grounds to cooperate with Central and South America, and further develop the technologies required by the Colombian water treatment industry.

3. Project Directions and Major Details

This project aims to accurately diagnose local conditions and technical demands by utilizing local networks including the KEITI Bogota office, local consultants, and ACODAL. By establishing a channel for technological cooperation between companies of both nations, a foundation can be provided for future matching of technology transfers. The major tasks and specifics of this project are illustrated in the following table.

Table 1 | Principal tasks and specific details of the project

Principal Tasks		Specific Contents	Notes
Nation-wide Diagnosis of Present Conditions (1)		· Macro Environment Analysis – Macro Economy, Core Industry, Water Treatment Policies and Present Conditions · Water Treatment Value Chain Analysis, Present Condition Investigation of Companies	· KSP Consulting team will utilize the local network.
Water Treatment Industry in Colombia Diagnosis of Present Conditions (2)	Analysis of Local Environ-ment	· WWT policies and infrastructure – Analyze present conditions and prospects for development of the WWT industry – Analyze the basic plans for water treatment and PPP policies of Colombia · WWT industry – Analyze present condition and prospect of the WWT industry – Investigate present condition of water treatment companies by value chain	· Methodology – General: Structured in-depth interviews, surveys – WWT industry: SWOT analysis, value chain analysis, local company investigation · KSP Consulting Team will conduct local data collection, interview with major organizations, and surveys.
	Capacity Diagnosis	· WWT policies and infrastructure – Analyze issues and limitations of water treatment industry policies – Derive policy implications for the introduction of PPP · Level of water treatment technology and technology in demand – Diagnose technological capacities by value chain, investigate technology demands	
Case Studies on the WWWT Sector in Korea		· Korea's WWT infrastructure – Analyze policies and case studies of WWT infrastructure that utilized PPP – Analyze cases of Korean companies participated in foreign PPP projects in the WWT sector · Comparative analysis between cases of Colombia • Korea and implications – PPP policy • institution in the WWT sector, available support, issues and response plans, etc.	· Methodology: – research precedents – advisory conference · Investigate exemplary cases for each analysis target

Principal Tasks	Specific Contents	Notes
Establishment of Technology Transfer Plans	・Select WWT technologies to transfer considering the local environment, technological capacities, and technology demands ・Establish a technology transfer model considering the characteristics of the WWT technology – 「①Technological issues diagnose → ②Advanced technical guidance→ ③Performance analysis → ④Follow-up measures」model design ・Select Korean companies that possess the technology to be transferred - 10-15 companies that have the willingness to transfer technology and cooperate ・Select 3-4 Colombian companies to receive the technology	・Methodology – Utilize the enterprise lists of Daegu TP and KEITI – Utilize the member company list of the Colombian Water and Wastewater Association – Screen and select (interview)
Capacity Building Workshop for Policy Administrators	・Invitees: appx 5 policy administrators from MVCT, MADS, the water and wastewater association, etc. ・Contents: Share Korea's experience in water treatment policies, visit core water treatment facilities that utilize PPP, visit relevant organizations, hold a seminar with experts, etc. – Discuss the course of action and schedules reflecting the demands of the IIC and relevant Colombian ministries – Hold Interim Report session ・Venue: Korea (Daegu, Seoul, Pohang, etc.)	・Composition – seminars with professionals, visits to relevant organizations or facilities ・Submit an interim report

The establishment of technology transfer plans begins with the diagnosis of technical levels by each value chain of Colombia's water industry and by discovering companies with demands. After selecting Korean companies to transfer water treatment technologies, a project briefing will be held to provide assistance in matching targets in each country and provide actual plans to proceed with the transfer of technologies.

Figure 2 | Implementation process of establishment of technology transfer plans

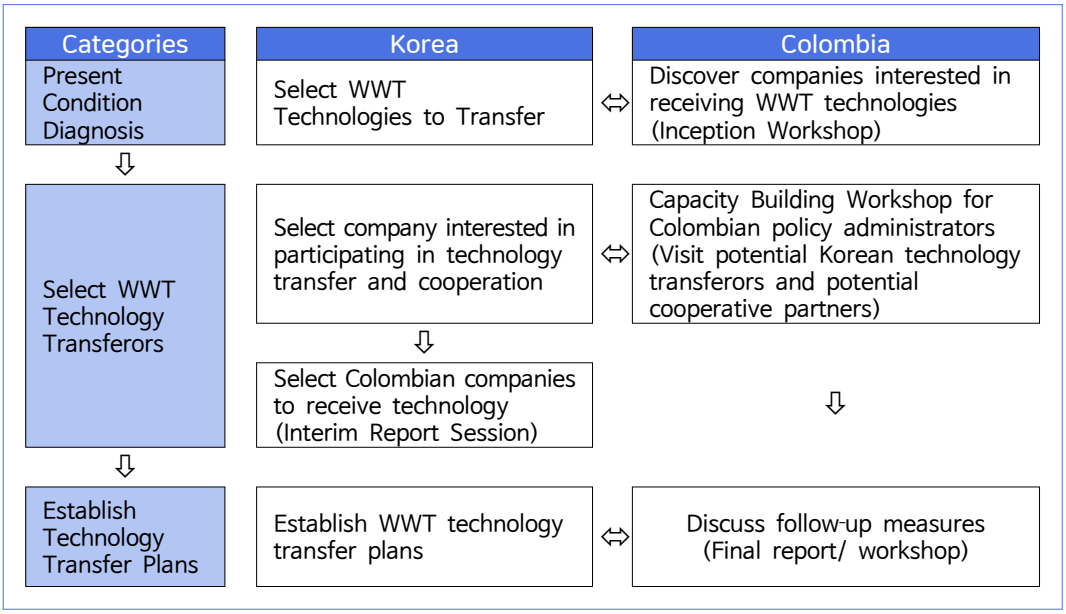
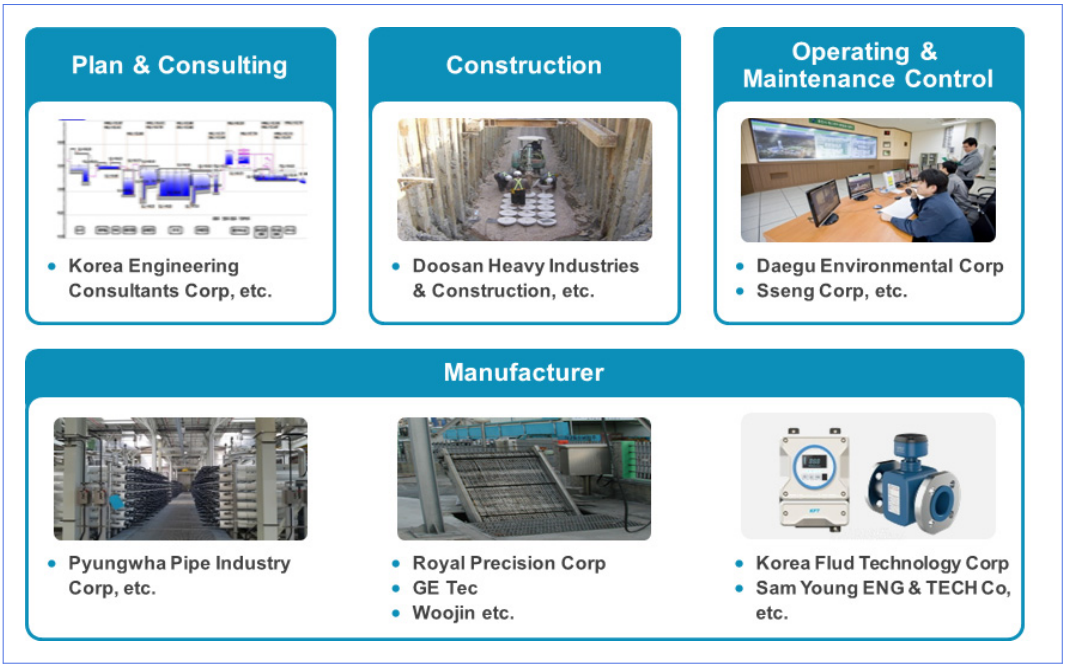


Figure 3 | Representative Water Industry Value Chain Companies of Korea (Example)



Ⅱ. Analysis of Colombia Water Treatment Status

1. Water Treatment Policy and Current Status

1.1. Environmental and Water Treatment Policy

Following the results from the United Nations Conference on Environment and Development (UNCED), Colombia adopted the “Rio Declaration on Environment and Development” and organized a new department dedicated to the preservation of the environment. To serve the goal of institutionalizing legal measures for the relief against sources of pollution, an environment pollution tax was introduced and environmental effects evaluation was mandated for large-scale construction projects. The goals of the Colombian government’s environmental policies are to provide a foundation for economic growth and flourishing democracy, and to preserve and restore the ecosystem. For this, environmental policies were designed to alleviate the impacts of climate change and to be adequate in the mid- and long-term, in consideration of the regional and national characteristics.

President Juan Manuel Santos established the Ministry of Environment and Sustainable Development in September, 2011 to strengthen the management of Colombia’s environment. Through the National Development Plan (PND), it aims to adjust to and alleviate climate change and constantly manage environment-related maritime and coastal regions through means not limited to management of water resources, preservation of forests, and protection of biodiversity.

In the national development plan (2010-2014) "Prosperity for All", integrated management of water resources was strengthened through more efficient distribution, reduction of unnecessary consumption, and improved supply and demand. The policy of ‘Integrated Management of Water Resources (PNGIRH) guarantees sustainability of resources through the link maintained with the ecosystem that regulates the land use and water supply, which further leads to efficient, effective use and management. More specifically, the policy includes the

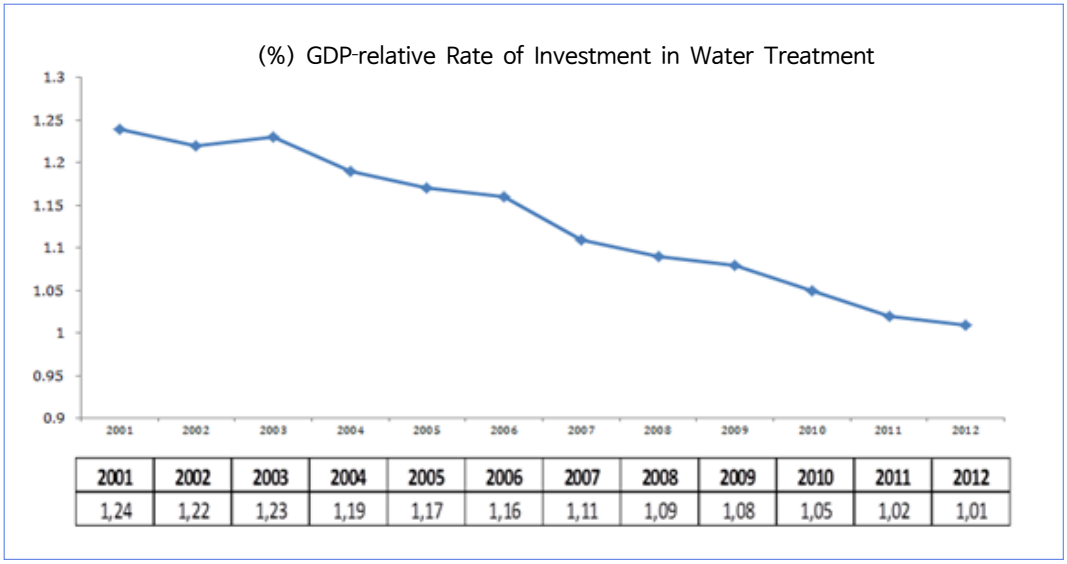
following points: program establishment and implementation for the integrative restoration of the Magdalena River basin, development, implementation, and monitoring of the program for Colombia's water management, national preservation and sustainable use of wetlands (lakes Tota, Fuquene, Cocha), and establishment of a method to identify flood-risk regions.

A project to improve the environment, including water resources and the sanitation level of 32 departments by 2019, was planned to provide less environmental pollution and better national health and hygiene. For integrated management of water resources (Gestión Integral del Recurso Hídrico), strategic plans were established for the Macro River basins of five regions of Magdalena. Guidelines were also set in order to guarantee the protection of 2.265 km3 of water and other resources in the regions of Cauca, Caribbean, Pacific Ocean, Orinoco, and Amazon.

A fund (Fondo de Adaptación) of 70,000 USD was raised to integrate management of 25 departments and 880 cities for the river basin management plan (Planes de Ordenación y Manejo de Cuencas), and the French International Cooperation Agency invested 3,500,000 USD for the restoration of Tota Lake (Lago de Tota, 55 km2) of Boyaca, which is the largest lake in Colombia.

On the other hand, the GDP-relative rate of investment in water treatment in Colombia is persistently decreasing, from 1.24% in 2001 to 1.01% in 2014.

Figure 4 | GDP-relative Rate of Investment in Water Treatment



2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1,24	1,22	1,23	1,19	1,17	1,16	1,11	1,09	1,08	1,05	1,02	1,01

Source : Colombia Environmental Market Status(KEIT,2015)

The government announced an intensive investment plan for the installment of water and sewage systems in rural areas for 2014 - 2024, but building contracts were fewer in 2015 since it was the last year in the terms of local governors. (They cannot sign contracts for the last 8 months of their terms according to law.)

Table 2 | Government Budget for Water Treatment in 2015

Ministry	Project Expenditures (10,000 USD)	Projects
Ministry of Agriculture and Forestry	4,500	Irrigation water
Ministry of Finance	6,800	Maintenance of water purification plants and pipes of benefitting regions
Ministry of Housing	77,400	56%: Water purification plants 24%: Sewerage 20%: Wastes and others
	5,700	Installment of waterworks and sewerage in rural areas

Source : Colombia Environmental Market Status(KEIT,2015)

The government departments in charge of water treatment are MVCT, MADS, DNP, etc., and SSPD has charge of their supervision and management.

Table 3 | Governmental Organizations in charge of Water and Sewage Systems in Colombia

Organization	Function
Ministry of Housing, City and Territory (MVCT)	Environmental Authorities: Project draft, review, order
Ministry of Environment and Sustainable Development (MADS)	
Regional Environmental Agency (CAR)	
Department of National Planning (DNP)	Establishment of policies and budgets
Department of Public Services Management (SSPD)	Control of management and services, supervision and inspection
Water and Sewage System Regulation Committee (CRA)	Mono-and oligopoly prevention in the public sector and price regulation

Source : Colombia Environmental Market Status(KEIT,2015)

Through VASB(Viceministerio de Agua y Saneamiento Básico), MVCT(Ministerio de Ambiente, Vivienda y Desarrollo Territorial) will monitor and evaluate drinking water and basic sanitation policies, strategies, programs and execute plans within Colombia, and simultaneously supervise the appliance of principles for effective business management in water supplies, sewage treatment and supply process of sanitation facilities.

MADS(Ministerio de Ambiente y Desarrollo Sostenible) is responsible for guiding and regulating national environmental systems and defining policies and regulations on the recovery, preservation, protection, organization, management, usage and sustainability use of renewable natural resources and the environment and ensure sustainable development. Responsible for planning and regulating environmental hygiene policies, general conditions, usage of renewable natural resources, management, preservation, restoration and recovery of natural resources, and conduct inspection and supervision of environmental authorities.

DNP(Departamento Nacional de Planeación) is an administration belonging to the government administrative and directly reports to the president. The main objective is to plan, monitor and evaluate results of policies, general planning of the public sector, and preparation of programs and business.

1.2. Water Treatment Regulations

In 2002, the government determined the priority and guidelines of sewage and wastewater treatment in the document CONPES 3117/2002 and listed it in the policy book of “Colombia Domestic Wastewater Management Plans” issued by MVCT and DNP.

Table 4 | Sewage Treatment Standards in Colombia (Ordinance no. 1594/1984)

Item	Existing Sewage Treatment Plants	New Sewage Treatment Plants
BOD_5	20% eliminated	80% eliminated
SS	50% eliminated	80% eliminated
pH	5 - 9	
Temperature	Under 40 ℃	Under 40 ℃
Precipitation	10 mL/L	10 mL/L
Hexane-soluble substances	100 mL/L	100 mL/L
Maximum velocity	1.5 fold of average velocity	1.5 fold of average velocity

Source: Colombia Environmental Market Status(KEIT,2015)

Adhering to this policy, MVCT, as the organization regulating the effusion of specific wastewater, announced Decree 3100/2003 that directly imposes a tax on water usage. Further actions were taken to regulate the establishment of hygiene plans and the management of wastewater from general households and sewage treatment companies. In relation to the improvement of economic measures to regulate usage of water resources, the announcement of Decree 155/2004 was effective, which imposed a tax on the use of groundwater.

Table 5 | Standard of Water Quality for Discharged Water in Colombia (Chemicals)

Element	Symbol	Value (mg/L)
Ammonia	N	1.0
Arsenic	As	0.05
Barium	Ba	1.0
Cadmium	Cd	0.01
Cyanide	CN-	0.2
Zinc	ZN	15.0
Chloride	Cl-	250.0
Copper	Cu	1.0
Color	Real Color	75 units, platinum-cobalt scale
Phenol compounds	Phenol	0.002
Chromium	Cr+6	0.05
Polychlorinated Biphenyls	Concentration of active agent	No detectable
Mercury	Hg	0.002
Nitrates	N	10.0
Nitrites	N	1.0
pH	Units	5.0 - 9.0 units
Silver	Ag	0.05
Lead	Pb	0.05
Selenium	Se	0.01
Sulfate	SO4=	400.0
Tensoactive/Surfactant	Methylene Blue Active Substance	0.5
Total coliforms	MPN	20,000 cells/100 mL
Fecal coliforms	MPN	2,000 cells/100 mL

Source : Colombia Environmental Market Status(KEIT,2015)

Table 6 | Standard of Water Quality for Water Supply in Colombia (Chemicals)

Element	Symbol	Value(mg/L)
Ammonia	N	1.0
Arsenic	As	0.05
Barium	Ba	1.0
Cadmium	Cd	0.01
Cyanide	CN^-	0.2
Zinc	Zn	15.0
Chloride	Cl^-	250.0
Copper	Cu	1.0
Color	Real Color	20 units, platinum-cobalt scale
Phenol compounds	Phenol	0.002
Chromium	Cr+	0.05
Polychlorinated Biphenyls	Concentration of active agent	Not detectable
Mercury	Hg	0.002
Nitrates	N	10.0
Nitrites	N	1.0
pH	Units	6.5 - 8.5 units
Silver	Ag	0.05
Lead	Pb	0.05
Selenium	Se	0.01
Sulfates	SO4=	400.0
Tensoactive/ surfactant	Methylene Blue Active Substance	0.5
Turbidity	JTU	10 Jackson turbidity units, JTU
Total coliforms	MPN	1000 cells/100 mL

Source : Colombia Environmental Market Status(KEIT,2015)

1.3. Water Treatment Status and Goals

The sewage treatment rate and waterworks and sewerage distribution rate of Colombia are very low compared to other countries, and there is high demand for improved facilities. Due to the deterioration of the existing waterworks and sewerage systems, 48% of households supplied with tap water, boil the water before drinking. The management system also has the problem of low efficiency.

According to the WHO/UNEP Monitoring Program, only 74% of the rural population enjoys the benefits of improved water resources, indicating that 45% of the purified water is leaking due to inadequate management.

As part of the "Environmental Improvement Project", the Colombian government aims to reach 100% and 82.2% of water system distribution rate in urban and rural areas, respectively, by 2019.

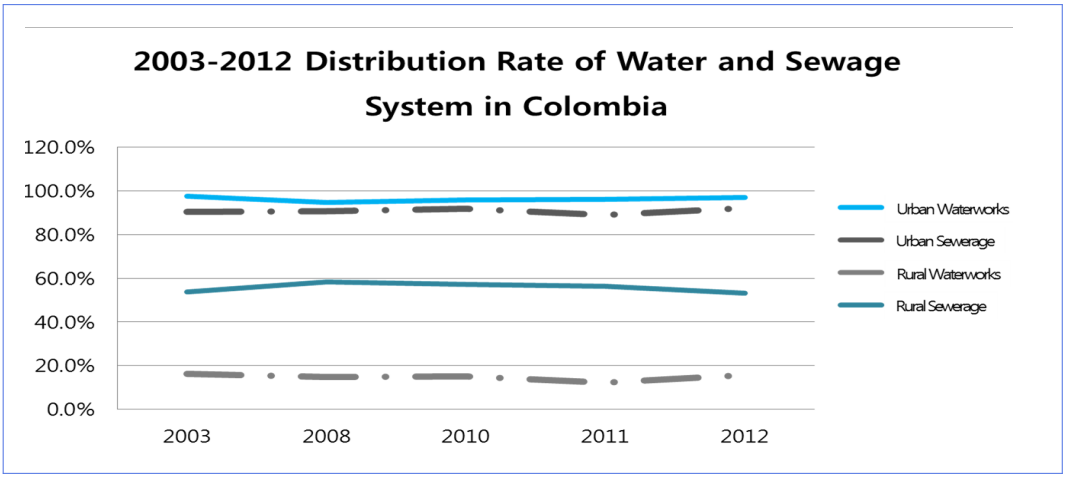
Table 6 | Plans for Distribution Rate of Water and Sewage Systems in Urban and Rural Regions of Colombia

Category		2005	2010	2015	2019
Urban	Waterworks	97.4%	98.5%	99.4%	100%
	Sewerage	90.2%	94.5	97.6%	100%
Rural	Waterworks	68.6%	75.1%	81.6%	82.2%
	Sewerage	57.9%	65.5%	70.95	75.2%
Wastewater Treatment Rate		8%	30%	-	50%

Source: DNP (2015)

From August, 2010 to the end of 2013, among those who did not have access to water and sewage systems in the past, 3,892,780 people (approximately 865,000 households) gained access to sewerage systems and 3,588,854 people (approximately 797,000 households) gained access to waterworks.

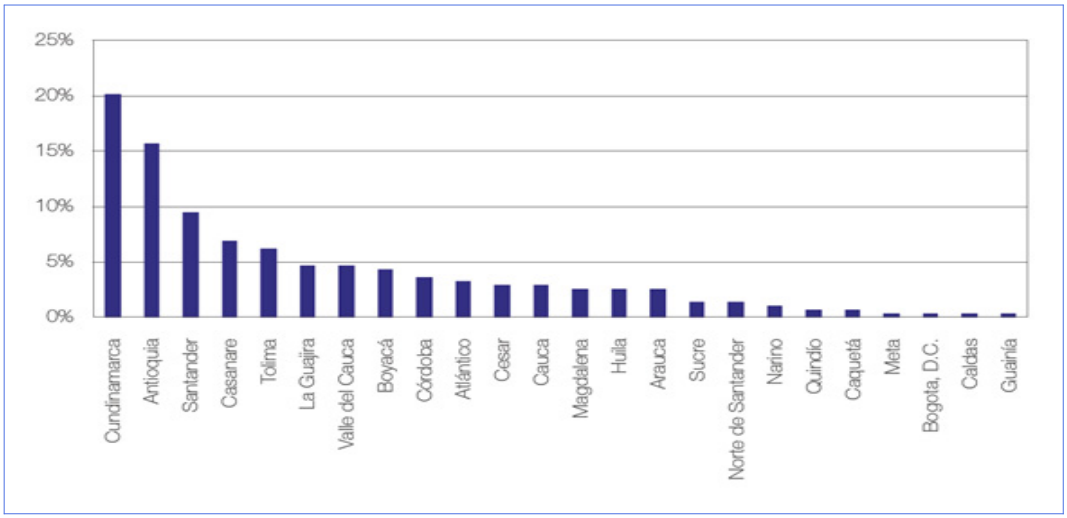
Figure 5 | Water and Sewage Distribution Rate in Colombia



Source: DANE (2013)

The distribution rates of water and sewage systems in the local governmental cities of Colombia are 96.8% and 92.4% respectively. The distribution rate of water in the capital area and in the Departments of Boyaca, Cundinamarca, Quindio, Caldas, and Risaralda is more than 99%, whereas the distribution rate of sewage in Quindio is 99%. The distribution rates of sewage in Colombia are based on the distribution rate of pipes rather than the rate of wastewater treatment. In fact, the wastewater treatment rates of local departments are less than 20%.

Figure 6 | Wastewater Treatment Rate by Department



Source: SSPD (2014)

The steady increase in the penetration rate of water and sewage has been rapidly increasing during 2011~2013 and the rate of water and sewage penetration is expected to improve further by continuous investment in accordance with government policy announcement.

Figure 7 | Trend of Waterworks Coverage

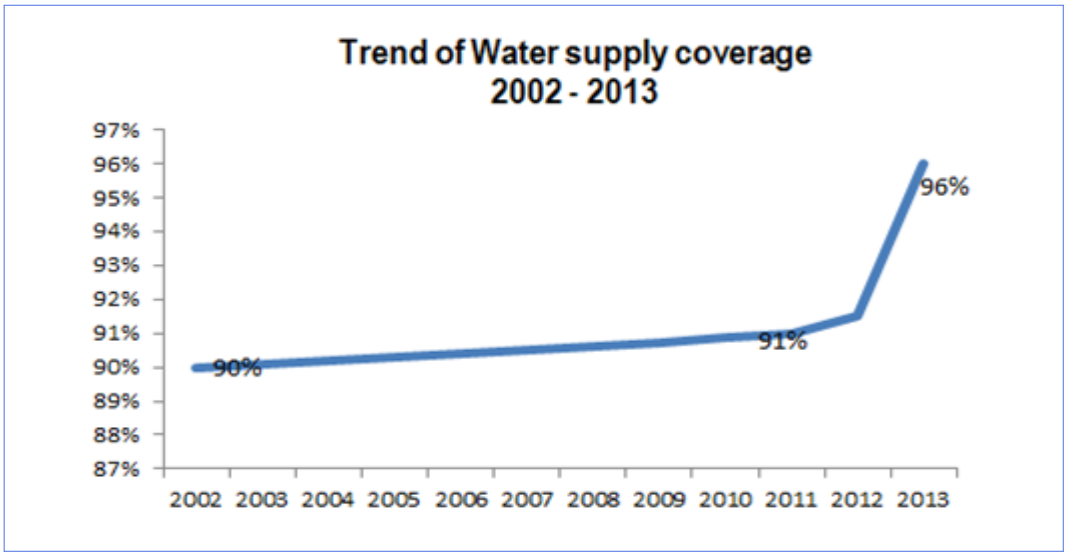
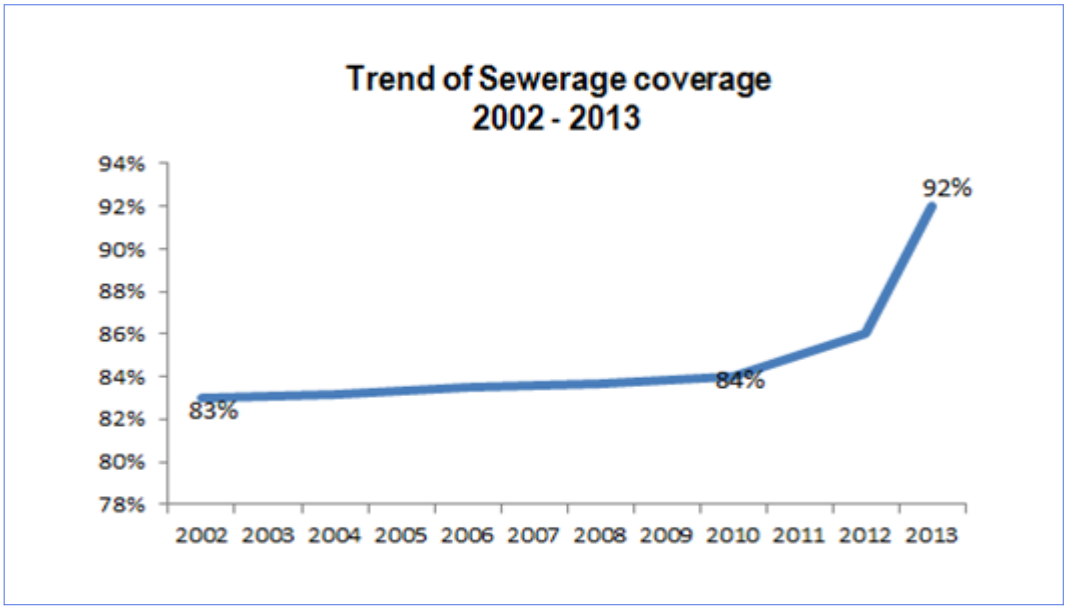


Figure 8 | Trend of Sewerage Coverage



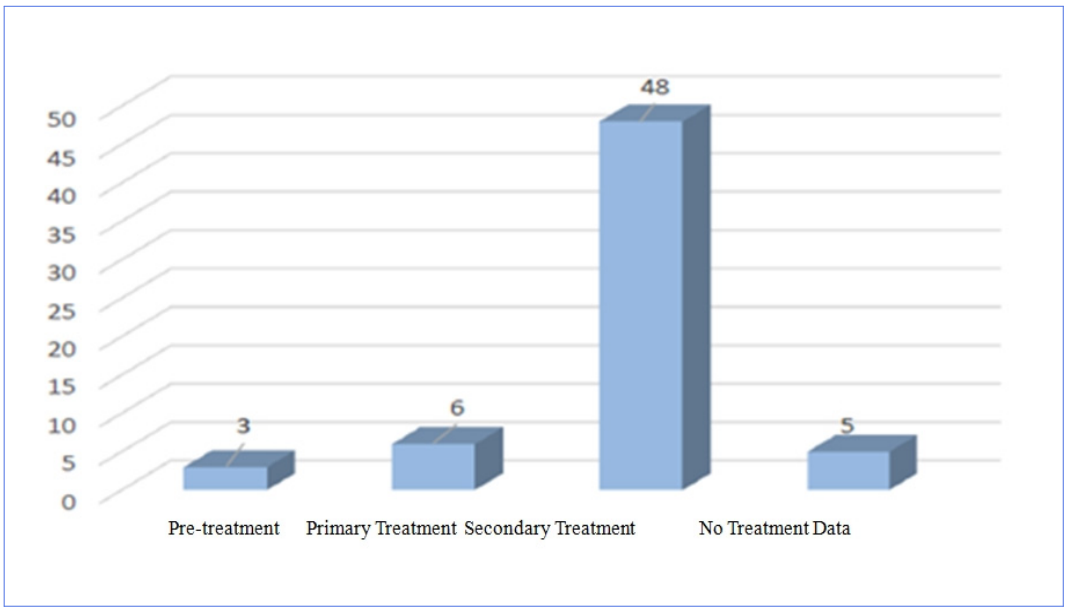
The data in Table 8 and Figure 9 suggests that there is a huge disparity between the statements from MVCT and SSPD, which are central governmental organizations, and subsequently the data have low reliability. Moreover, in many cases, the actual treatment rates do not meet the standards of the design, which requires secondary treatment.

Table 8 | Wastewater Treatment Plants of Colombia

Items	No. of Treatment Plants	Treatment Capacity (tons/sec)
Pre-treatment	14	1.35
Primary treatment	33	8.66
Secondary treatment	224	13.15
Total	271	23.18

Source: MVCT (2014)

Figure 9 | Wastewater Treatment Plants of Colombia



Source: SSPD (2015)

According to the current state of sewerage by basins in Colombia, the number of treatment plants is the highest in the Bogota River basin while the sewage treatment rate is the highest in the Cauca River basin.

Table 9 | Wastewater Treatment by River Basins in Colombia

Basin	Wastewater Discharge Flow (L/sec)	Wastewater Treatment Capacity (L/sec)	Treatment rate (%)	No. of Treatment Plants
Bogota River (Rio Bogota)	19,440	6,630	34.1	37
Cauca River (Rio Cauca)	11,860	6,869	57.9	26
Medellin River (Rio Medellin)	7,260	1,306	18	1
Chinchina River (Rio Chinchina)	998	0	0	0
Otun River (Rio Otun)	1,353	0	0	0
Fonce River (Rio Fonce)	114	15.8	13.9	5
Fuquene River (Rio Fuquene)	256	51.4	20.1	3

Source: SSPD (2015)

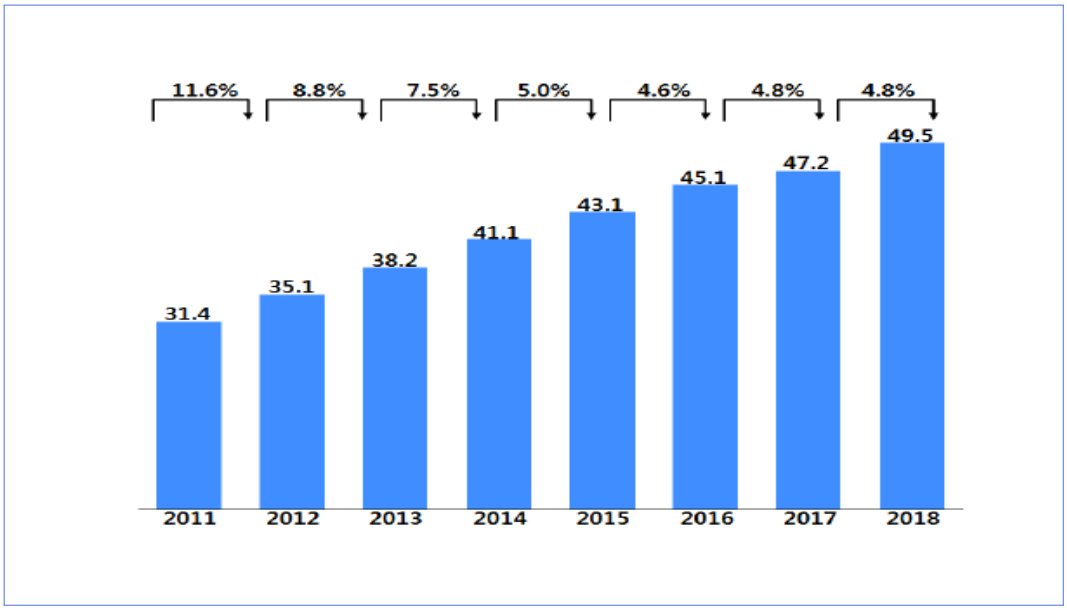
2. Water Treatment Industry

2.1. Water Market Status and Prospects

The water market of Colombia was worth 3.8 billion USD in 2013, and is expected to continue a trend of annual average growth of 5%, reaching 4.9 billion USD in 2018. As one of the largest economies in South America, Colombia will seek to increase opportunities for foreign water companies to enter, in order to expand the water market and increase the efficiency of government-led water industries, following future economic growth.

Figure 10 | Water Market Status and Prospects

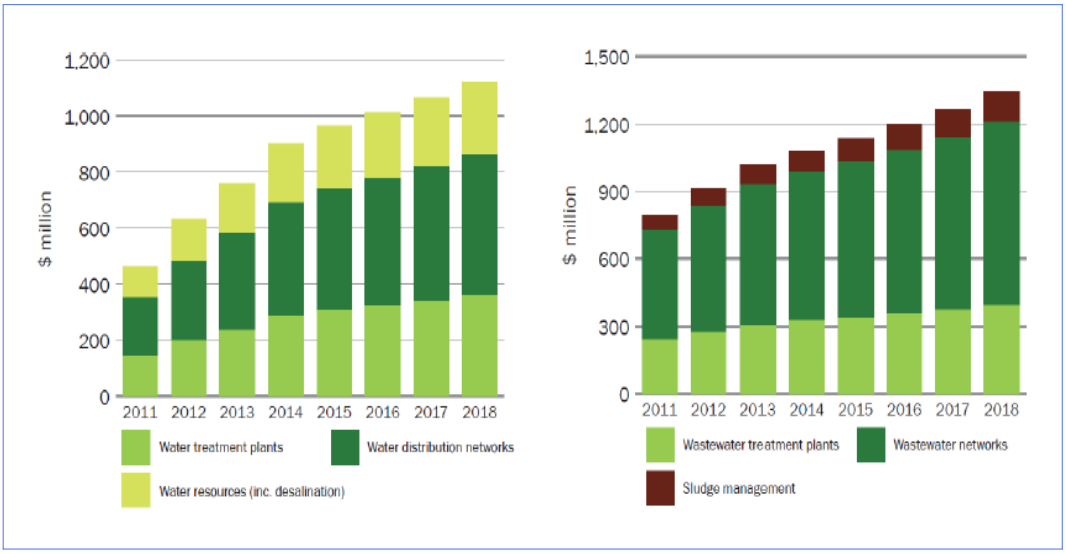
(unit: hundred million USD)



Data Source : GWI

The water supply market was worth 760 million USD in 2013, and is expected to grow to 1.1 billion USD by 2018. The sewage market is also expected to show rapid growth, from 1 billion USD in 2013 to 1.3 billion USD in 2018.

Figure 11 | Current Status and Prospects of Water Market in Colombia



Data Source : GWI

The Colombian government is informing the citizens of the importance of the water industry and endeavoring to resolve environmental issues as soon as possible, thus rapid growth is expected. Investments are most likely in the repair and improvement of deteriorated waterworks and sewage distribution facilities, in upgrading water treatment plants, and in setting up new systems.

Considerable investment is expected in the future due to the PDA (Waterworks and Sewerage Improvement Plans) policy currently being promoted in order to achieve the UN Millennium Development Goals by 2019. Because most of the current Colombian waterworks and sewerage facilities are deteriorated, O&M (operation and maintenance) or monitoring system markets, in particular, are expected to show rapid growth. This is also true of maintenance services for already polluted rivers. The major environmental projects planned in Columbia through 2019 include the establishment of a wastewater treatment plant in Canoas, expansion of wastewater treatment plants in Bello and Salitre, and construction of the Bucaramanga Dam.

The Colombian government has recently announced plans to place grand investments worth 10.4 billion COP (Colombian Pesos; 3.6 billion USD) in the water industry. The fields of major investment include improvement of facilities for waterworks and sewerage, irrigation water, drinking water, reusing river waste, and energy plant facilities. This project is referred to as ‘Ciudades sosstenibles y competitivas’, and will be conducted as 1500 sub-projects in 400 cities and districts.

The biggest parts and materials market in Colombia is the pipes market, followed by automated measuring devices, valves, and fittings. The parts and materials markets in Colombia are expected to exhibit continuous growth in relation to the repair and construction of waterworks, sewerage pipes, and treatment plants.

Table 10 Current Status and Prospects of Material/Component Market in Colombia

	2011	2012	2013	2014	2015	2016	2017	2018
Equipment (utility and industrial)								
Pipes	124.6	150.9	172.3	190.6	201.7	211.5	223.2	235.8
Pumps	61.4	76.0	87.4	97.9	104.1	109.6	116.2	122.9
Valves / fittings	47.3	59.3	68.7	77.9	82.8	86.8	91.6	96.6
Screening / grit removal	15.6	18.3	20.4	22.2	23.0	23.5	24.4	25.0
Agitation / mixing / settling	21.9	26.3	30.1	33.8	36.1	38.1	40.6	43.1
Aeration / flotation	26.7	31.7	36.3	40.6	43.6	46.7	50.3	54.0
Non membrane filtration	12.8	16.1	18.7	21.6	23.2	24.4	26.0	27.4
Disinfection	15.2	18.8	21.7	24.7	26.3	27.7	29.3	31.0
Chemical feed systems	10.5	12.6	14.4	16.2	17.2	18.1	19.2	20.3
Automation and control	44.3	56.1	66.0	76.3	82.7	88.6	95.8	103.2
Test	12.4	15.4	17.9	20.5	22.0	23.5	25.1	27.8
Meters	11.2	15.3	18.3	21.6	23.1	24.2	25.4	26.7
MF / UF	0.8	1.0	1.1	1.3	1.4	1.5	1.6	1.7
RO / NF	1.6	1.9	2.2	2.5	2.7	2.8	3.1	3.2
Thermal process equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ion exchange / EDI / adsorption	1.5	1.6	1.7	1.9	2.1	2.1	2.5	2.7
Sludge thickening / dewatering	14.4	17.4	19.0	19.6	21.0	22.9	24.6	26.5
Anaerobic digestion	4.6	5.4	6.4	7.0	8.0	8.8	10.3	11.6
Sludge drying / thermal processes	8.0	9.7	11.0	11.5	12.9	14.1	15.2	16.7
Other sludge stabilisation	3.1	4.0	4.8	5.3	6.1	6.7	7.5	8.5
Other equipment	86.8	103.5	116.8	127.8	134.2	140.1	147.2	153.9
Total equipment	**524.7**	**641.3**	**735.2**	**820.6**	**873.9**	**922.0**	**979.4**	**1,038.7**

Data Source : GWI

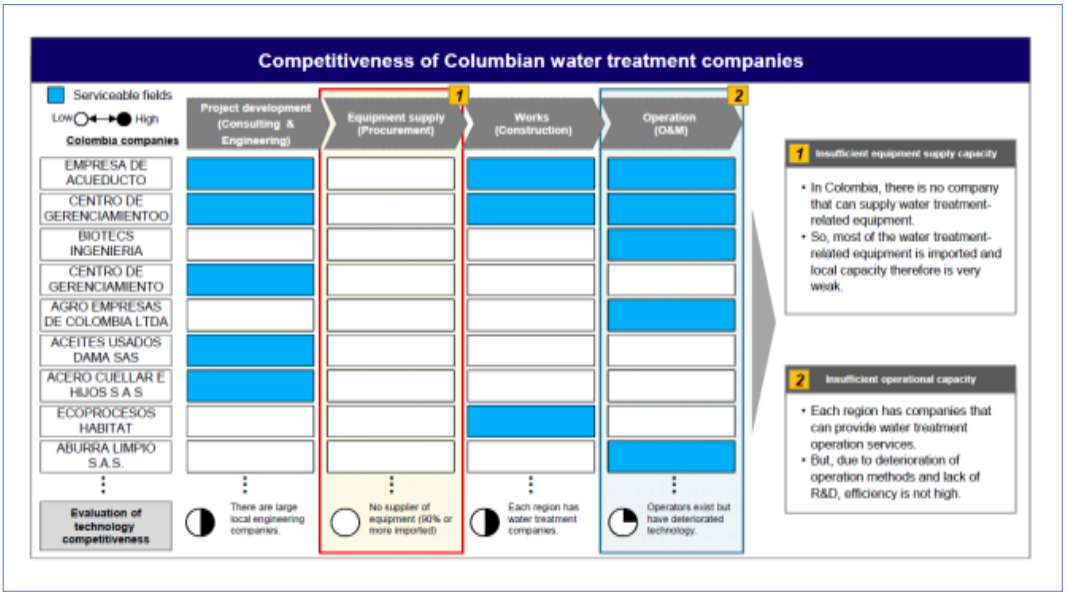
2.2. Water Treatment Technology and Companies

The low technology of Colombian water treatment companies hinders development of the fundamental solutions needed for the water treatment related issues of Colombia. Local companies cannot individually solve the problems in the fields of manufacturing and O&M, in particular.

Manufacturers capable of supplying equipment related to water treatment are almost non-existent in Colombia, and thus most of the required equipment is imported from overseas. It can be concluded that the self-sustainability of water treatment is extremely low.

There are companies able to provide water treatment management services in each region, but these suffer from low efficiency due to the lack of management know-how and R&D.

Figure 12 | Competitiveness of Columbian water treatment companies

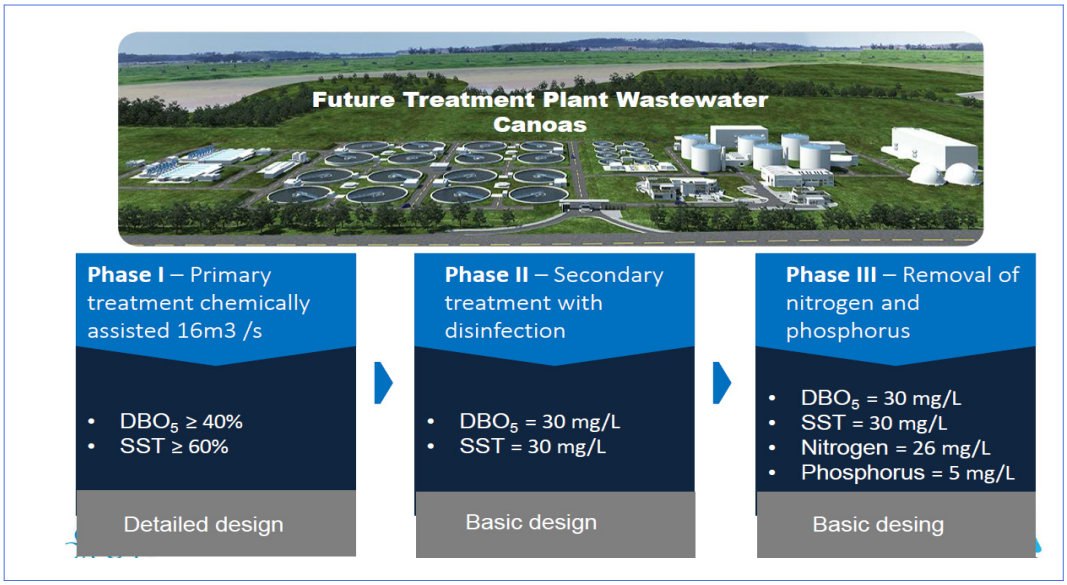


When transferring technology to Colombia, the best choices would be those that are consistent with the local water quality standards, and that fit the local situation with technology that can be easily transferred and for which training is easy. It would also be important to use energy-efficient tools and materials, and to introduce technologies that could provide low management cost and greater sustainability. Looking into the recently established facilities and planned projects will provide insight in determining the water treatment technologies appropriate for Colombia.

For instance, at the Canoas Sewage Treatment Plant (STP), which is currently being planned for construction, the water will go through three levels of treatment: first chemical treatment, followed by sterilization, and then elimination of nitrogen and phosphorus. Most of the designing is near completion, and has the following goals for each step Level 1: BOD 40 - 60%, suspended solids treated; Levels 2 and 3: BOD 30 mg/L, suspended solids (after treatment) 30 mg/L, nitrogen content 〈 26 mg/L, and phosphorus content 〈 5 mg/L.

Thus, the biosolids in the sewage are expected to gradually stabilize, as 471 m3, 667 m3, and 764 m3 of them are eliminated (isolated) during each step of the treatment process (level 1 - 3). Stabilized biosolids can be classified as group A (〈 1000 fecal coliform cells per gram) or group B (〉 1000 but 〈 2 million coliform cells per gram). In order to fulfill the prerequisites of achieving group A or B, heavy metals must be eliminated from the original water.

Figure 13 | Plan of the Canoas Sewage Treatment Plant



Data Source : EAB of BOGOTA, 2016

The sewage and solid waste treatment plants constructed in the 1970s in Korea, mostly adopted the active sludge process. This was because this process was most advantageous in providing good water quality due to the use of a primary settling basin; considering the substantial fluctuations in water flow and concentration caused by Korea's sewer conditions and monsoon climate. This process is also considered to be adequate for Colombia's current situation because the management and maintenance are relatively easier than with processes involving biological membranes.

There was some difficulty in gathering information about the water treatment related companies of Colombia. Based on the member catalog of ACODAL, Colombia's waterworks and sewerage association, the field of activity and main products were listed for each company. After reviewing information of about 100 members in the catalog, 30 companies were discovered to be manufacturers for, or otherwise relevant to, water treatment; these are listed below 〈Table 11〉.

Table 11 | Water Treatment Related Companies in Colombia

No	Company Name	Field of Activity and Main Products
1	Acuatecnica LTDA	Water purification, sewage treatment, water treatment (industrial, recreation/swimming pool, amusement parks, etc.), waterworks and sewerage design, construction
2	Alzogroup	Provide orientation and technical advice to companies and organizations in various fields including food and beverages, petro-chemicals, paper manufacture, irrigation system, hotels and hospitals, recreation, government, etc.
3	American Pipe	Sales of pipes for waterworks, sewerage and irrigation, technical assistance, design, and manufacturing
4	Aquasoft S.A.	Import, assembly, sales and exports of water pipes
5	Asequímicos S.A.	Manufacturing chemical agents, chemical engineering, technical advices. Manufacture, import, and sales of chemicals and parts used in the field of water treatment and in the chemical industry
6	Aqua Colombia EV LTDA	Provides treatment services for drinking water, sewage, industrial water and wastewater. Constructs and installs treatment factory in prfv. Provides channels, sedimentation modules, storage, ore dressing systems, etc.
7	Brinsa S.A.	Manufacturing and sales of chemical products
8	BTP Medidores y Accesorios S.A.	Manufacturing of water resource meters and water pipe connecting tap parts Own brand: AQUAFORJAS
9	CDM Smith, Inc.	Provides engineering and construction services for water resources, environment, transportation, energy, and other infrastructure
10	Colempaques S.A.S.	Manufactures plastic products: water storage line, sewage treatment line, sanitation line, waste collecting, agriculture/stock breeding line
11	CORPACERO S.A.	Leading and specialized company in the field of manufacturing metal products for construction and industry in general. Products: metal drifts, section steel, zinc roof tiles, metal pipes, ARMCO products
12	Ecolosystems Colombia S.A.	Design, construction, management, and maintenance of living wastewater treatment plants that minimize occurrence of sludge. Provides water treatment related technologies to governmental organizations and private corporations.
13	EDOSPINA S.A.S	Design, manufacture, assembly of factories, facilities, and systems for treatment of sewage, drinking water, and industrial water. Sales and assembly of equipment.

No	Company Name	Field of Activity and Main Products
14	Filmtex S.A.S.	Manufacturing of PVC membranes
15	Hidroconsulting S.A.S.	Consulting, sales, and construction. Water resource urban engineering, telemetry, remote control. Manufacture control valves, special steel parts.
16	Helbert y Cia. S.A	Manufacturing and sales of water, vapor, and air valves. Represents domestic and international manufacturers of hydraulic valves and water pumping systems, and supplies equipment and special valves for flood preparation. Provides technical consulting for the designs, assembly, and running of industries, water pipes, buildings, shopping malls, and agricultural pumps.
17	Industrias Fibratank UST C.A.	Manufactures storage systems (tanks) for the storage of water or other liquids underground or in external glass fibers.
18	GPT an EnPro Industries company	Manufactures insulating packaging and kits for protection systems of cathodes, insulators, packed pipes.
19	Premier Coatings, Ltd.	Manufactures 100% epoxy sheaths, Archoco Rigidon (tank lines) internal and external protection systems, and maritime and coastal structures.
20	Metalúrgica Construcel Colombia Metacol SA	Production and sales of steel products for the running of fluids, including valves, hydrants, parts, floodgates, covers, etc. Steel-related engineering services, assembly, civil engineering
21	P.V.C. Gerfor S.A.	Manufactures tap PVC tiles and pipe system. Supplies geosystems.
22	Tecnologia de Polietileno de Colombia TPC. S.A.S.	Manufactures pipes and sells polyethylene parts. Installment. Manufactures pipes and polyethylene parts for delivering drinking water, gas, and industrial water (PPR).
23	Tigre Colombia S.A.S.	Produces construction related products such as ducts, pipe lines, plastic polymers, etc.
24	Química Integrada S.A.	Production and sales of chemical agents for various water treatments. Technical assistance.
25	Acuatubos S.A.	Production and sales of products for the transportation of fluids.
26	Accesorios y Válvulas Apolo S.A.- AVA S.A.	Manufacturing of valves, parts, and hydrants for handling fluids.
27	Powerseal S.A	Manufactures parts required for the repair, maintenance, and expansion of transport networks for water, gas, and petroleum
28	Tepco Corema S.A.S.	Manufactures polyethylene and polypropylene pipes
29	Colombiana de Extrusion S.A EXTRUCOL	Manufactures polyethylene pipes for gas, water, mines, telecommunications, waterworks, urban engineering, agriculture, and irrigation
30	Tecca	Industrial wastewater, Beverage and food processing plant, Plating factory, Dyeing factory, Household sewage treatment facility Plant maker

Data Source : ACODAL data rearrangement

Ⅲ. Analysis of Korea Water Treatment Status

1. Water Treatment Policy and Current Status

1.1. Water Industry Policy

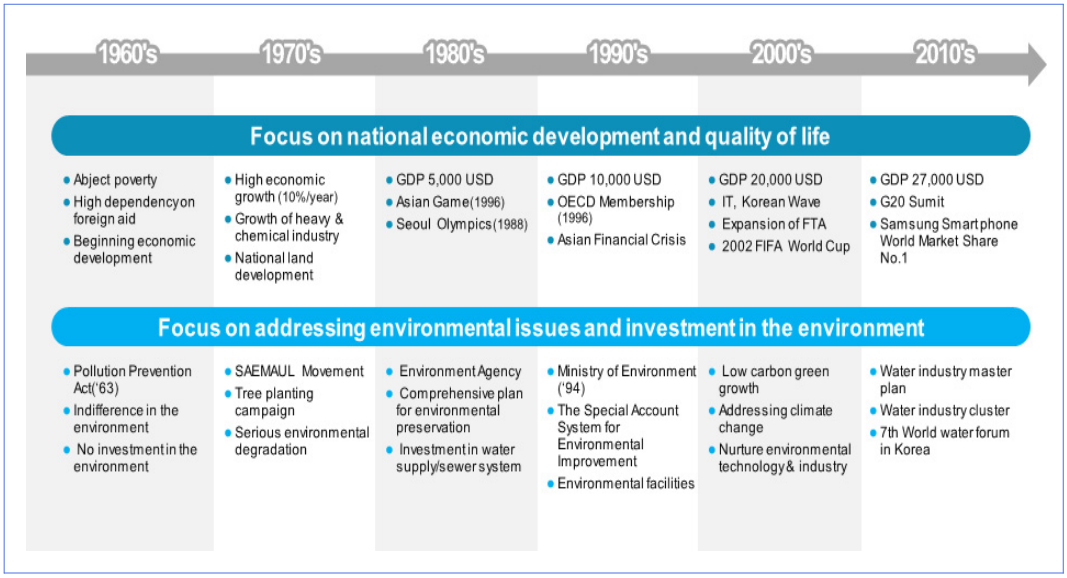
Figure 14 | Progress of Water Industry Promotion Policies

Major Programs	Main Contents
Water Industry Promotion Program ('06. 2)	◈ Reform waterworks and sewerage, Consolidate competitiveness through privatization ◈ Promote related industries including water reusing and drinking spring water
Water Industry Competitiveness Consolidation Program ('10. 9)	◈ Develop original technology such as eco-smart waterworks, etc. ◈ Foster related industries and water-specialized enterprises
Promotion of Water Industry and Vitalization of Overseas Expansion ('12.2)	◈ Develop technology, reform waterworks and sewerage, foster related industries ◈ Create new water market and expand to different regions
Basic Strategy for Development of New Water Industry ('14. 9)	◈ Build water industry cluster ◈ Invest in infrastructure for all phases of water circulation and prepare for future

Thanks to the enormous amount of investments made in the industrial sector by the Korean government, the GDP per capita increased from 80 dollars in 1963 to 27,000 dollars in 2016, leading to rapid growth of the economy. However, the economic boost was followed by severe

environmental pollution, thus effort to overcome such problems were also required. The government aimed for qualitative growth by harmonizing environment and economy through green growth, green technology and industry, and responses to climate change.

Figure 15 | History of Water Management



In management of the water environment, the government is moving away from the water environment policy focused on physicochemical pollutant management such as BOD, etc. and putting the national and ecosystem health as the top priority of the policy. In 2006, the 'Water Environment Management Basic Plan' ('06.9.25) has been established to embody the policy direction for the next 10 years with the goal of 'Creating safe water environment from pollutants and ecologically healthy rivers'.

First, we established a water environment management system which is hydro-ecological focal and strengthened the hydro-ecological restoration project. Also, in addition to strengthening the watershed focused water quality management system by expanding the water pollution total amount management system, it introduced the nonpoint pollution source installation reporting system and established and prosecuted with 'The 2nd nonpoint pollution source management comprehensive countermeasures ('12.5) and expanded the management method for nonpoint pollution sources. We have reinforced the risk management by subdividing the environmental standard grade from 5 to 7 and added COD, T-P, TOC items and also have prosecuted the enhancement of hydrologic cycle structure and made foundation of water demand management such as improvement of old water pipes and water conservation, etc. In order to achieve such policies, a total of 33.4 trillion won has been invested over the past ten years.

Table 12 | Sectoral investment performance of Water Environment Management (2006~2015)

Categories	SUM	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
SUM	334,107	23,784	23,655	26,150	35,831	32,708	32,712	35,819	39,471	41,510	43,206
Aquatic ecology restoration	44,188	2,575	2,575	3,268	5,276	3,709	3,546	3,946	6,636	6,311	6,816
Ecology risk management	33,521	1,790	2,024	2,131	2,702	3,034	3,023	4,846	5,034	4,743	4,194
Nonpoint source	5,408	95	90	250	261	348	544	749	825	1,209	1,037
Livestock wastewater treatment plant	8,563	239	195	453	943	1,023	949	1,231	1,330	1,294	906
Sewerage	242,405	18,816	18,771	20,047	26,649	24,594	24,651	25,048	25,645	27,953	30,231

Source : Environmental Report 2017

There are 18 pieces of legislation currently enacted regarding water, including the Act on River controlled by the Ministry of Land, Infrastructure, and Transport. These can be classified into the fields of water quantity control and water quality control, and are subject to amendments and enactments in accordance with changes in socioeconomic conditions.

Table 13 | Legislation by Department

Department	Legislation	Department	Legislation
Ministry of Land, Infrastructure and Transport	Act on Rivers Act on Dam construction and Resources of Surrounding regions Groundwater Act	Ministry of Agriculture, Food and Rural Affairs	Act on the Rearrangement of Agricultural and Fishing Villages Act on the Prevention of and Countermeasures against Agricultural and Fisheries Disasters Tide Embankment Management Act
Ministry of Environment	Framework Act on Environmental Policy Act on the Preservation of Water Quality and Hydro-ecological System Act on Water Supply and Waterworks Installation Sewerage Act Act on the Water System of the Four Rivers Act on the Management of Drinking Water Act on the Promotion and Assistance of Water Recycling	Ministry of Maritime Affairs and Fisheries	Act on the Maintenance and Reclamation of the Shared Waterside Act on the Development and Maintenance of Deep Ocean Water
		Ministry of Government Administration and Home Affairs	Act on Hot Springs
		Ministry of Public Safety and Security	Act on the Prevention of and Countermeasures against Natural Disasters Small River Maintenance Act

The Framework Act on Environmental Policy, Act on the Preservation of Water Quality and Hydroecological System, Sewerage Act, Act on the Management of Drinking Water, and the Act on the Promotion and Assistance of Water Recycling are presently relevant to water quality and environment, and the specific purposes of each legislation are illustrated in the following table.

Table 14 | Acts related to Water Quality and Environment

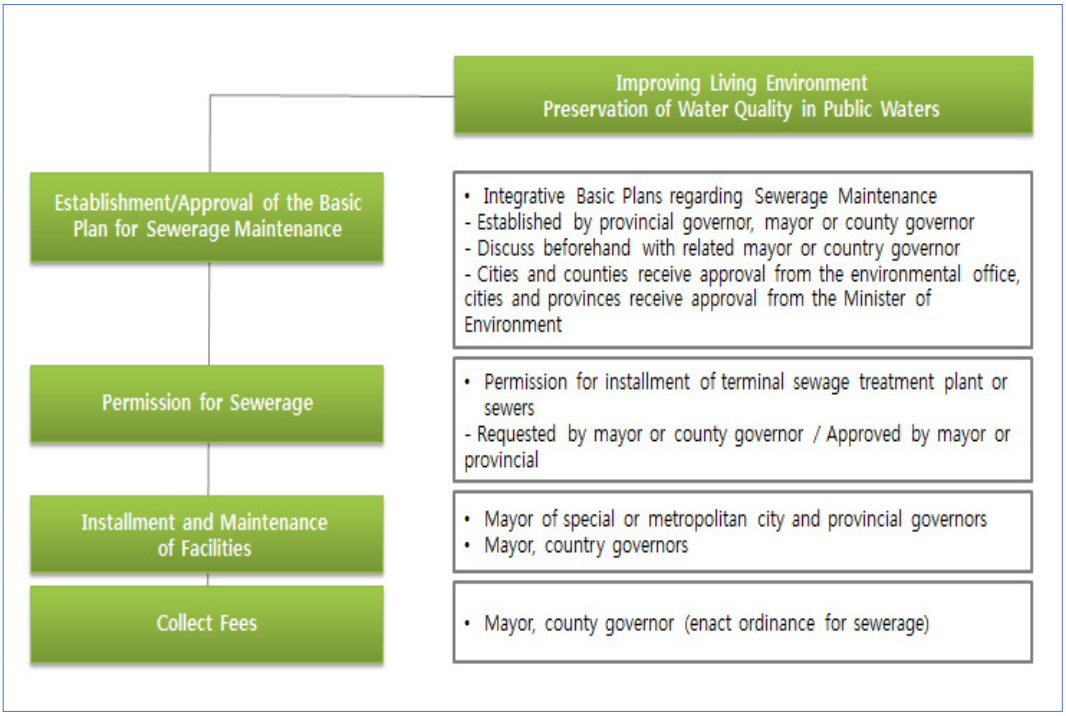
Legislature	Purpose
Framework Act on Environmental Policy	Allow all citizens to enjoy a healthy, pleasant life by clearly defining the people's rights and duties, and the state's responsibilities regarding the preservation of the environment, deciding the basic aspects of environmental policies to prevent environmental pollution and damage, and manage and preserve the environment appropriately and sustainably.
Act on the Preservation of Water Quality and Hydro-ecological System	Allow all citizens to enjoy the benefits and bequeath them to future generations by preventing damage to public health and environment caused by water pollution, and appropriately manage the water quality and hydro-ecological systems of shared watersides such as rivers, lakes, and marshes.
Sewerage Act	Decide on the standards for the installation and management of the sewerage system to appropriately treat sewage and excreta in order to contribute to the enhancement of public hygiene and healthy improvement of the local communities and preserve the water qualities of public waters.
Act on the Management of Drinking Water	Reasonably manage the water quality and hygiene of drinking water to contribute to improving public health.
Act on the Promotion and Assistance of Water Recycling	Promote water recycling to efficiently utilize water resources and aim for a sustainable use of water resources by reducing harmful impacts on water quality, eventually improving the quality of life of the citizens.

1.2. Current Conditions and Policy Trends of Domestic Sewerage

1.2.1. National System for Public Sewerage Management

Appropriate treatment of the sewage produced in their districts of jurisdiction is the intrinsic duty of the local governments, and thus it is also their responsibility to install and manage the sewerage. For the treatment of sewage in their districts, local governments establish basic plans for sewerage maintenance every 20 years and update the plans after validity reviews every five years. They install sewerage according to the basic plan for sewerage maintenance.

Figure 16 | Summary of Public Sewerage Management System



1.2.2. Current Condition of Sewerage

The Cheonggyecheon Wastewater Treatment Plant (WWTP) was first built in 1976 with the treatment capacity of 150,000㎥ per day, whereas the 「Law of Sewerage」 was enacted in 1966. The duties regarding sewerage were transferred from the Ministry of Construction and Transport (currently Ministry of Land, Infrastructure and Transport) to the Ministry of Environment in 1994.

As of the end of 2014, the sewerage distribution rate, calculated as the ratio of population in the zone with wastewater treated by the public treatment plants and terminal treatment facilities to the total population, was 92.5%. The number of currently operating public WWTPs with treatment capacity 〉 500 m3/day is 597 (total capacity of 24,751,820 m3/day), and the number with treatment capacity 〈 500 m3/day is 3160 (total capacity of 247,578 m3/day).

The statistical increase in the sewerage distribution rate from 39% in 1992 to 92.5% now can be said to be the result of intensive investment in the construction of wastewater treatment plants since the Seoul Olympics in 1988 and the integrative program to supply clean water in 1989.

Table 15 | Current Condition of Sewerage

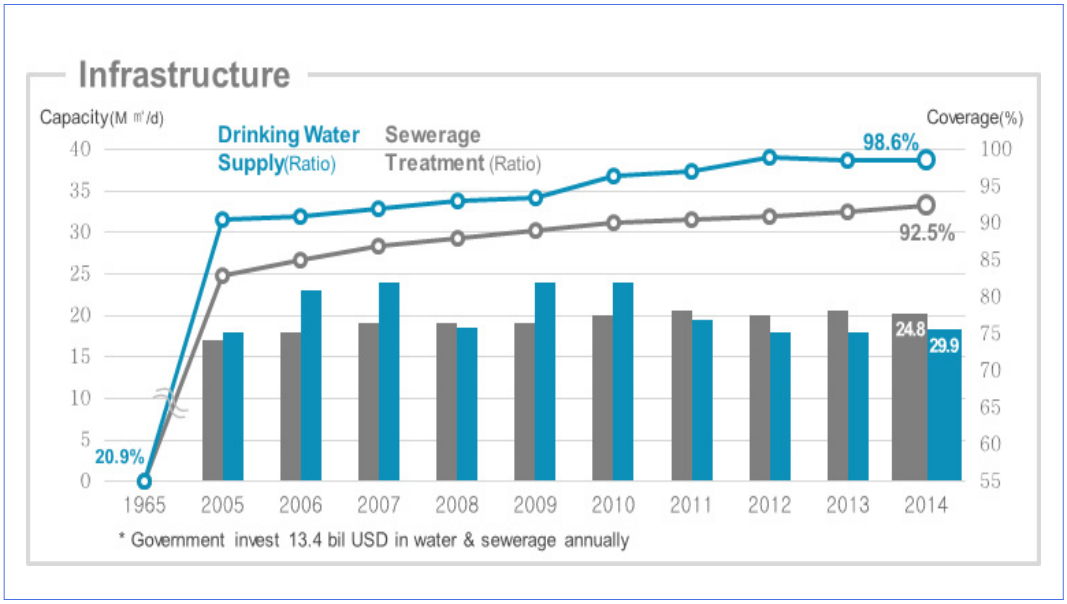
Categories	2007	2008	2009	2010	2011	2012	2013	2014
Total Population (1000 people)	50,034	50,394	50,644	51,435	51,717	51,881	52,127	52,419
Treatment Population (1000 people)	43,570	44,631	45,263	46,358	47,034	47,538	48,016	48,506
Treatment Plants (number less than 500 m3/day)	357 (1,854)	403 (1,991)	438 (2,332)	470 (2,594)	505 (2,858)	546 (3,067)	569 (3,205)	597 (3,160)
Distribution rate (%)	87.1	88.6	89.4	90.1	90.9	91.6	92.1	92.5
Total Capacity (1000 tons/day)	23,942	24,568	24,925	25,118	25,228	25,297	25,330	24,999

Source: Sewerage Statistics (Ministry of Environment)

The total length of the installed sewerage was 132,680 km by the end of 2014, which is 77.8% of the planned length (170,472 km) according to the basic plan for sewerage maintenance. Within this, the length of combined sewers that drain rain water and wastewater simultaneously is 44,601km (33.6%), wastewater only sewers account for 51,813 km (39.1%), and rain water only (storm) sewers account for 36,266 km (27.3%).

Regional gaps still appear within the sewerage coverage. The sewerage distribution rate for Seoul is 100% whereas for South Jeolla Province, which mostly consists of rural areas,it is 69.1%.

Figure 17 | Water and Sewage Treatment in Korea



1.2.3. Sewerage Policy Trend

By establishing integrative plans for the national sewerage system according to Article 4 of the Law of Sewerage, the Republic of Korea aims to consistently provide the blueprints and directions for the sewerage policies to serve the basic principle of the nation to promote systematic development of policies and projects.

1) The First National Integrative Sewerage Plan (2007-2015)

Following amendment of the Law of Sewerage (enacted 9.28.2007), the Ministry of Environment established and announced the 「National Integrative Sewerage Plans」 to suggest the directions for the policies regarding sewerage in Korea. This plan serves as the basis for the systematic development of policies and efficient promotion of projects regarding sewerage systems. Furthermore, it provides guidelines for local governments or environmental authorities to follow in implementing policies and projects.

Until now, policies regarding the sewerage system were established and implemented based on large-scale expansions of public sewage treatment plants centered around cities, and included consideration of pending issues. This plan is based on long-term views, and strives to increase the sewerage distributions rate of rural areas through balanced investments to regions and introducing sewerage management systems by river basin to allow more efficient installment and management of sewerage systems. It also aims to make sewage a resource by treatment and reuse, and strengthens the functions of sewerage systems such as preventing inundation during heavy rain and managing nonpoint pollution sources.

Reviewing the performances of the First National Integrative Sewerage Plans based on 2013 statistics, continuous expansion of sewage treatment plants led to 92.1% of coverage, which is the level of developed nations. Through increased sophistication of sewage treatment facilities (94%), 3071 tons (BOD) of the daily pollutant load was reduced, allowing a cleaner water environment. The efficiency of sewage treatment systems was also enhanced through the maintenance of sewer pipes, including the conversion to separate systems (64.1%). The overall efficiency of the sewage management field was increased by opening up technological inspection and management to the private market.

Table 16 | The First National Integrative Sewerage Plans (2007 - 2015)

◇ Suggested a new direction for policies regarding the sewerage system until 2015 by evaluating past policies and projects regarding the sewerage system

- o Improved equity of sewerage services between regions such as urban and rural areas
  - Sewerage Coverage Total 83.5% (2005) → 92% (2015)
    Rural 35.8% (2005) →75% (2015)
- o Integrative maintenance of the sewerage system and gradual change to separate sewer system
- o Reinforce management of rain water and nonpoint pollution, improved water circulation through making use of treated sewage
- o Reinforce basis for management of sewerage by introducing management systems by river basins, etc.

◇ Invest total 27.4 trillion KRW by 2015

- o 8.1 trillion KRW for the maintenance of sewer pipes for a pleasant environment
- o 15.5 trillion KRW for the installment of public sewage treatment facilities for the preservation of water quality in public waters
- o 3.8 trillion KRW for other projects including rain water management

◇ Features of National Integrative Sewerage Plans

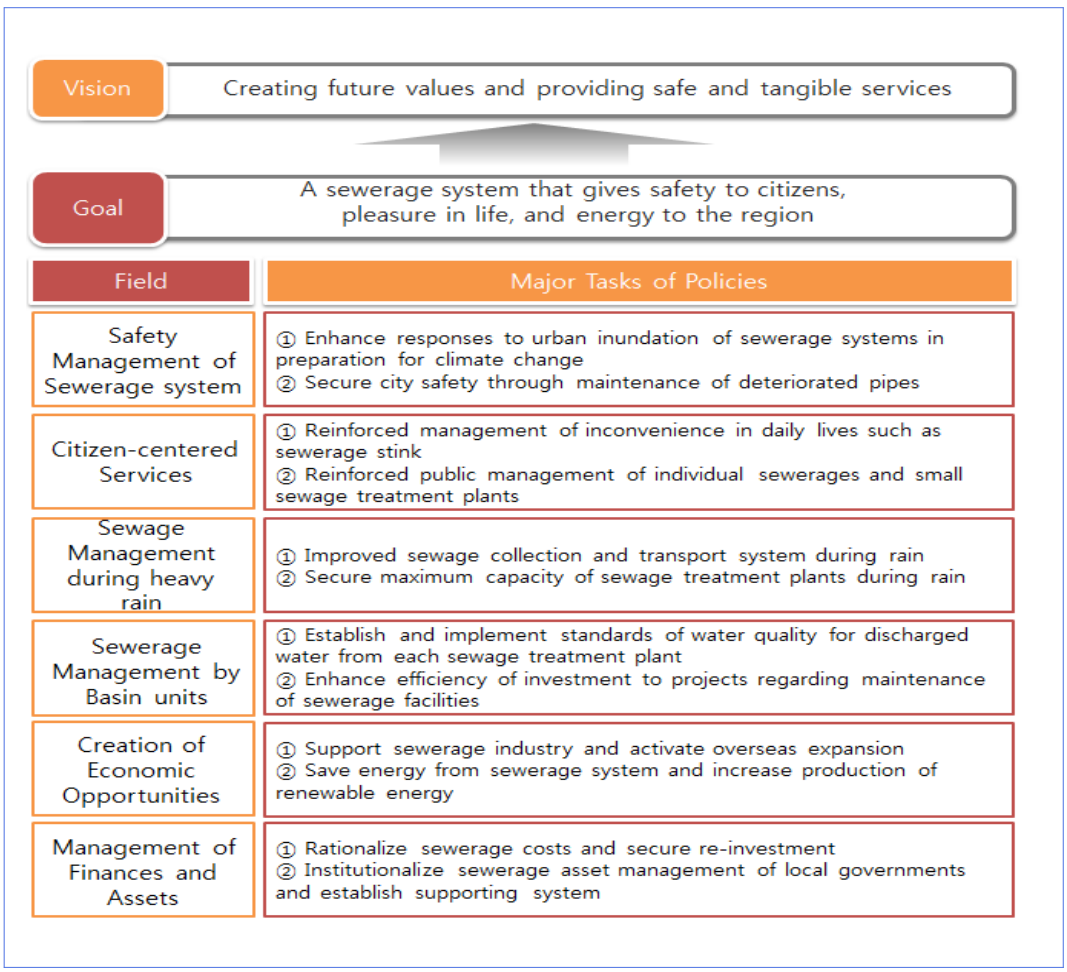
Previous Sewerage Plans		2015 National Integrative Sewerage Plans
o Investments concentrated in constructing large-scale public sewage treatment plants and resolving pending issues	⇒	o Balanced investments by regions and enhanced efficiency of sewerage management
o Separated construction of sewer pipes and sewage treatment plants	⇒	o Simultaneous maintenance of sewer pipes and sewage treatment plants
o Emphasis on sewage treatment	⇒	o Sewerage facilities that treat and reuse sewage
o Rain water management neglected	⇒	o Reinforced sewerage functions for preventing inundations and managing nonpoint pollution sources
o Sewerage managed by administration units	⇒	o Sewerage managed by river basins
o Avoided by residents	⇒	o Used by residents
o Introduction of foreign technology	⇒	o Internationalized domestic technology

Source: Ministry of Environment

2) The Second National Integrative Sewerage Plan (2016-2025)

The Second National Integrative Sewerage Plan aims to create future values and provide safe, tangible services in order to construct a sewerage system that gives safety to citizens, pleasure in life, and energy to the region. It aims for enhanced major indicators (baseline is 2015, goal is 2025), which include public sewerage coverage 92.1% → 96.0% (63.2% → 80% for rural areas), recycling rate of sewage sludge 51.5% → 75%, and reuse rate of treated wastewater 12.6% → 25%.

Figure 18 | The Second National Integrative Sewerage Plans (2016 - 2025)



1.3. The Proposed Quality Standards for Released Water of Sewage Treatment Facility

The Korean standards for the quality of water released from domestic sewage treatment plants were first established in the 「Environmental Pollution Prevention Act」 in October, 1964. It is applied to four different treatment methods (activated sludge process, trickling filter process, precipitation, others) with items of pH, BOD, SS, and total coliform colonies. Since the amendment of the 「Enforcement Ordinance of the Sewerage Act」 in March 1983, only the items of the standards for the released water quality (BOD, SS) were suggested, regardless of the process method. Afterwards, the standards were changed through repeated amendments of the enforcement ordinances. The specific changes of the standards are stated in the following table. (National Institute of Environmental Research, 2013).

Table 17 | The Proposed Quality Standards for Released Water from the Environment Conservation Act (March 1983) to the Sewerage Act (January 2012)

Categories	3.1983	7.1993	1.1996	10.2001[1)]	7.2009[2)]	1.2011	1.2012[3)]
BOD (mg/L)	30	30	20	10	10	10	5
COD (mg/L)	-	50	40	40	40	40	20
SS (mg/L)	70	70	20	10	10	10	10
T-N (mg/L)	-	-	60	20	20	20	20
T-P (mg/L)	-	-	8	2	2	2	0.2
Total Coliform Colonies (number/mL)	-	-	-	3,000	3,000	3,000	1,000
Ecological toxicity (TU)	-	-	-	-	-	1	1

Note : 1) Specific region, 2) Daily sewage treatment capacity over 50 m3, 3) Region (over 500 m3: I - IV Regions)
Source: A Study on the planning of Improvement for Effluent Standards of Sewage Treatment plants, 2013, National Institute of Environmental Research

Table 18 | Establishment System and Items of Quality Standards for Released Water in Four Countries

Categories	Korea	USA	EU	Japan
Establishment System	- Specific establishment system nonexistent - General: Based on technical accounts (BPT, Research in 2004) - Total phosphorus (T-P) levels are different for each region based on water quality accounts	- POTW is regarded as a type of business and is applied with the NPDES license system. - The government suggests general items (3) of standard - Individual standards: water quality accounts, technical accounts	- Achievement of the target level of water quality (entire water quality accounts) - Approach based on technical accounts - Assessment of treatment technologies	- Specific establishment system nonexistent (water quality accounts and technical accounts are combined)
Items of Standard	- 7 items including BOD, COD, SS, T-N, T-P, total number of coliform groups and ecological toxicity	- Number of monitored items by scale: under 400 tons a day (3), under 4000 tons a day (10), more than 4000 tons a day (11+ toxic substances) - Toxicity references in case of industrial wastewater influx - Diversification of nitrogen control including ammoniacal nitrogen, TKN, NOx-N, etc. - Addition of chloride ion, TDS, DO, etc.	- Different items by scale (based on units rather than the amount of sewage) - BOD, COD, SS, T-N, T-P, - Different standards for each item in each country: ammoniacal nitrogen (Germany) - Includes approval standards for influx of toxic substances	- pH, number of coliform colonies, SS, BODs, T-N, T-P - Standards applied by process methods adopted by each treatment facility - The terminal treatment plant is applied with both quality standards for released water according to the Sewerage Act and the quality standards for water released into public waters (including toxic substances).

Source: A Study on the planning of Improvement for Effluent Standards of Sewage Treatment plants, 2013, National Institute of Environmental Research

The United States of America and other countries in Europe apply both the technical accounts and the water quality accounts in order to establish the quality standards of water released from sewage treatment facilities. They also apply various monitoring methods including ecological toxicity monitoring on all the items that can be introduced to the system in order to control the toxic substances. The water management in Japan, which is very similar to that in Korea, allows local governments that manage sewage treatment facilities to set even stricter quality standards for released water and require industrial wastewater treatment facilities to abide by the effluent standards of the Water Pollution Prevention Act. The following table (Table 18) lists the establishment system and items of quality standards for water released from sewage treatment facilities in the USA, EU, and Japan (National Institute of Environmental Research, 2013)

1.4. Comparision of Water Treatment in Korea and Colombia

1.4.1. Water Treatment Legislation

There are two types of governmental 'water management system': the 'diversified system' and the 'comprehensive system'. The former refers to a system in which the power over water management is distributed among many departments, whereas the latter refers to a system in which such power is focused in a single or very few departments. The USA and Japan have adopted the 'diversified system' while the UK, France, Germany, and The Netherlands have adopted the 'comprehensive system'.

In Korea, water-related acts are divided among the Ministry of Land, Infrastructure and Transport, Ministry of Environment, Ministry of Government Administration and Home Affairs (The Ministry of Public Safety and Security), Ministry of Agriculture, Food and Rural Affairs and the Ministry of Maritime Affairs and Fisheries. Therefore, Korea is a country with a 'diversified system' and no particular department leading water management. In the bigger picture, the Ministry of Land, Infrastructure, and Transport is in charge of the water quantity whereas the Ministry of Environment manages water quality, and they are leaders in amending related legislation. The major drawback of this system is that the quantity and quality of water has to be taken into consideration simultaneously for the most effective water management, but it is not. Therefore, there is a need for a comprehensive water management team.

As shown in the following table, Colombia is also diversified in terms of water management, so a comprehensive department is considered necessary. When comparing Korea and Colombia, the establishment of a regular plan for legislation in Korea has proven an advantage. As shown in Table 19, major legislative plans for each law are regularly established to

complement and develop relevant facilities and policies. For example, in the case of the waterworks maintenance plan (master plan), each water service provider (municipality) is to establish it every ten years, and it is prescribed by law to allow changes every five years to reflect major changes. Colombia also proceeds with major planning when necessary, but it does not appear to be making regular plans by statute. It can be concluded that regular planning is necessary for the best development of water treatment in Colombia.

Table 19 | Comparison of Water Management Legislation System of Both Countries

Category	Korea	Colombia
Water Regulation System	Diversified System	Diversified System
Major Department in Charge	MOLIT (Water quantity) Ministry of Environment (Water quality)	MVCT (Water quantity) MPS (Water quality)

Table 20 | Korea's System of Water Treatment Legislation

Category	Legislation	Department in Charge	Official Plan
Water Quantity Management	Act on Rivers	MOLIT	Long-term Comprehensive Plan for Water Resources
			Comprehensive Water Control Plan
			General Plan for Small Rivers
	Act on Dam Construction and Resources of Surrounding Regions	MOLIT	Long-term Construction Plan for Dams
	Groundwater Act	MOLIT	General Plan for Groundwater Management
	Act on Hot Springs	MOI	Comprehensive Plan for Hot Spring Development
	Act on the Development and Maintenance of Deep Ocean Water	MOF	General Plan for Deep Ocean Water
	Act on the Maintenance and Reclamation of the Shared Waterside	MOF	General Plan for Reclamation of the Shared Waterside
	Act on the Rearrangement of Agricultural and Fishing Villages	MAFRA	Rationalization Plan for Utilization of Agricultural and Fishing Water

Category	Legislation	Department in Charge	Official Plan
Water Environment and Water Quality Management-related Legislations	Framework Act on Environmental Policy	Ministry of Environment	Environment Preservation Plan
	Act on the Preservation of Water Quality and Hydro-ecological System	Ministry of Environment	Preservation Plan for Water Quality and Hydro-ecological System of Large Influence Areas (General Plan for Water Environment Management)
			General Plan for Total Pollutant Management
			Non-point Pollution Source Management Plan
	Act on the Improvement of Water Quality of the Water Supply Source in the Han River Water System and Community Support, etc.	Ministry of Environment	General Plan for Total Pollutant Management of the Han River Water System
	Act on the Water Management of the Nakdong River Water System and Community Support, etc.	Ministry of Environment	General Plan for Total Pollutant Management of the Nakdong River Water System
	Act on the Water Management of the Yeongsan River Water System and Community Support, etc.	Ministry of Environment	General Plan for Total Pollutant Management of the Yeongsan River and Seomjin River Water Systems
	Act on the Management and Utilization of Livestock Manure	Ministry of Environment	General Plan for Livestock Manure Management
	Act on the Promotion and Assistance of Water Recycling	Ministry of Environment	General Plan for Water Recycling
	Waterworks Act	Ministry of Environment	General Plan For Waterworks Management
			Comprehensive Plan for Water Demand Management
	Sewerage Act	Ministry of Environment	General Plan for Sewerage Maintenance
	Act on the Management of Drinking Water	Ministry of Environment	-
	Act on the Management of Maritime Environment	MOF	Comprehensive Plan for Maritime Environment
Disaster Prevention-related Legislation	Act on the Prevention of and Countermeasures against Natural Disasters	MPSS	Comprehensive Plan for Reduction of Damage from Storms and Floods
	Small River Maintenance Act	MPSS	Comprehensive Plan for Small River Maintenance

Table 21 | Colombia's System of Water Treatment Legislation

Main Role	Department in Charge	Major Fields and Functions
Legislative Body	DNP	• Establish national plans • Distribute investments in different sectors
	MVCT	• Establish and manage policies of various sectors • Provide support for administrative districts and cities • Organize waterworks and sewage treatment programs
	MPS	• Set and monitor standards for drinking water quality
	MADS	• Regulate environment
Regulation Supervision and Control	CRA	• Enact economic regulations for providing living, water and energy • Prohibit activities that limit competition • Manage, inspect and supervise supply of public living water and energy
Organization and Execution	Comprehensive Project Management (Each department)	• Include projects funded by a number of banks • Distribute investments in different sectors
	Environmental organizations	• Execute environmental management policies ·Evaluate, manage, and supervise water resources
	Government in charge of administrative district	• Organize programs for the region • Provide technical, institutional and financial support to service providers
	Local government	• Manage supply of drinking water and purification treatment in rural regions
	Government delegation based on local community	• Able to provide waterworks and sewerage in rural regions

1.4.2. Water Quality

An overview comparison of the Colombian and Korean drinking water quality standards and the discharge water quality standards is provided in Table 22.

Table 22 | Comparison of Water Quality Standards of Columbia and Korea

Category	Item	Korea	Colombia
Standards of Drinking Water Quality	Number of items	60	35
	Comparison of major items	Turbidity below 0.5 NTU	Turbidity below 2 NTU
Standards of Quality of Water Discharged from Sewage Treatment Plants	Number	7 items (BOD, COD, SS, TN, TP, Total coliform colonies, ecological toxicity)	7 items (BOD, SS, pH, temperature, precipitation, hexane-soluble substances, maximum velocity)
	Comparison of major items	BOD below 10	BOD 80% removed

In terms of water quality standards for drinking water, Korea is more likely to invest in safe tap water production because there are more items on the standards, and the technical level is also higher as most standards are followed. In addition, turbidity, the most representative indicator of water quality, is controlled to a much higher standard, indicating the production of cleaner water. Thus, the transfer of Korean know-how for water treatment in such fields will be beneficial.

The number of discharged water quality standards is the same, but nutrients such as nitrogen and phosphorus are not included in the statutory water quality standards of Colombia. Thus advanced treatment is not required, leading to a lower level of control, and even BOD is considered in relative percentage, indicating a significantly lower level of water treatment compared to Korea. There can be many reasons and differences in comparisons of managed water quality, but there is clearly a need for Colombia to strengthen its water quality standards. The Korean technology will be helpful for development of water treatment technologies such as advanced treatment.

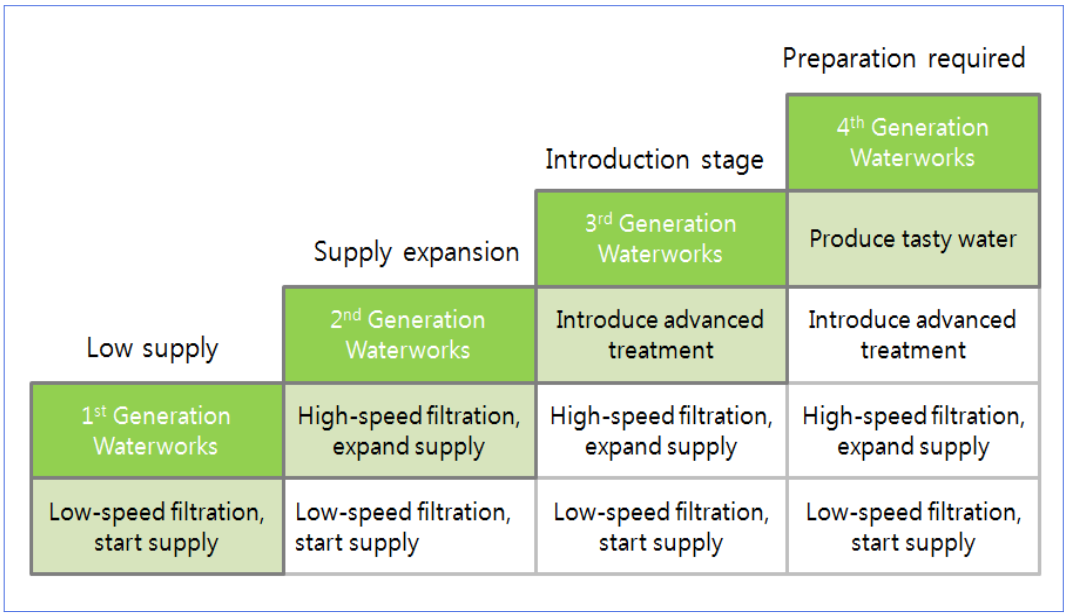
1.4.3. Evaluation of Water Treatment Development

When estimating the development of waterworks in Korea according to the process level based on the model of the sewage development stage on the environmental white book, the first generation refers to low speed filtration, disinfection, and distribution in metropolitan cities. The second generation comprises high speed filtration, general processing, and national distribution of waterworks. In the third generation, advanced treatment processes are introduced, and the fourth generation focuses on producing tasty water and building block

systems. There are regional differences in Korea, but water supply and technological development have generally already reached third - fourth generation.

Colombia water treatment is in second generation, which mainly deals with general process treatment following expansion of water supply and rapid filtration. It has not yet introduced advanced processes for treating taste, odor, and trace substances, indicating a relatively slow development of its waterworks. Of course, there is a high level of technical understanding, such as the introduction of membrane filtration to industrial facilities. However, the policy to prioritize expansion of the distribution of water to regions without supply is preferred.

Figure 19 | Developmental Stages of Waterworks



Source: Environmental White Paper

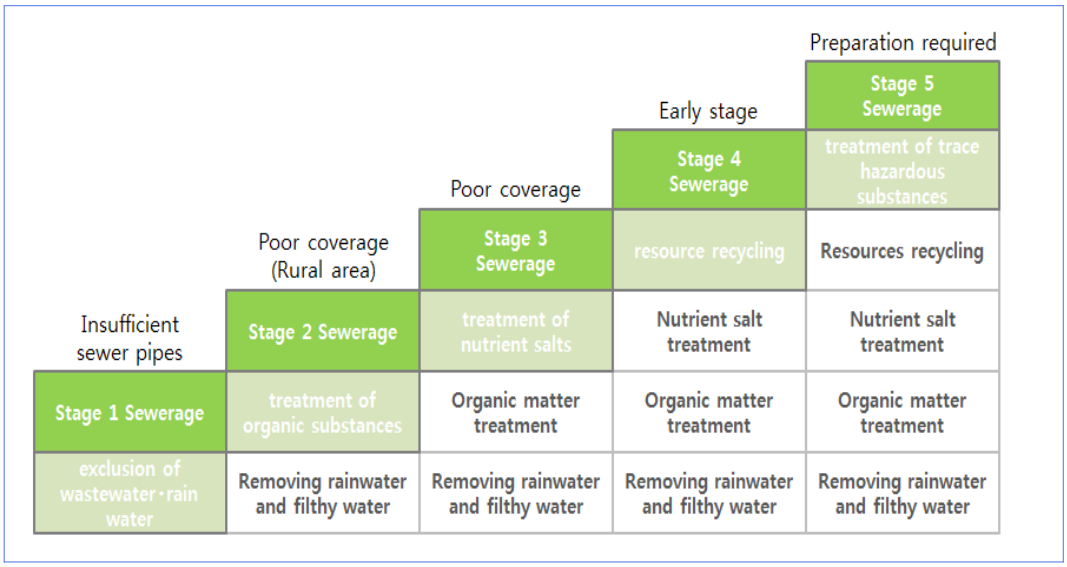
Table 23 | Comparison of Waterworks in Korea and Colombia

Category	Korea	Colombia
Distribution rate (%) (2014)	98.6	96
Development stage	3 - 4th generation	2nd generation
Water quality standards	NTU	2 NTU

Source: Waterworks Statistics (Ministry of Environment)

In general, the developmental stages of sewerage systems are classified as follows. Stage 1 is drainage of wastewater and rainwater (also called storm water). Stage 2 involves treatment of organic substances with treatment of nutrient salts occurring at Stage 3. Resource recycling occurs at Stage 4, and treatment of trace hazardous substances takes place at Stage 5. Korean sewage treatment simultaneously includes various stages, such as Stage 2 with expansion of sewers in rural areas and Stage 4 with promotion of resource recycling and self-sufficiency energy projects. Whereas Korea is considered to have entered Stage 4 in terms of available technology and is moving toward Stage 5, WWT in Colombia remains between Stages 1 and 2, indicating that the development of the sewerage system has fallen considerably behind.

Figure 20 | Developmental Stages of Sewerage Systems



Source: Environmental White Paper

Table 24 | Comparison of Waterworks in Korea and Colombia

Category	Korea	Colombia
Distribution rate (%) (2014)	92.5	Under 20*
Developmental Stage	Stage 3 - 4	Stage 1 - 2
Water Quality Standards	BOD: 10 mg/l SS: 10 mg/l	BOD, SS 80% eliminated (e.g. 60 mg/L when water quality of inflow is 300 mg/h)
No. of Treatment Plants	3,757	271

Source: Sewerage Statistics (Ministry of Environment)

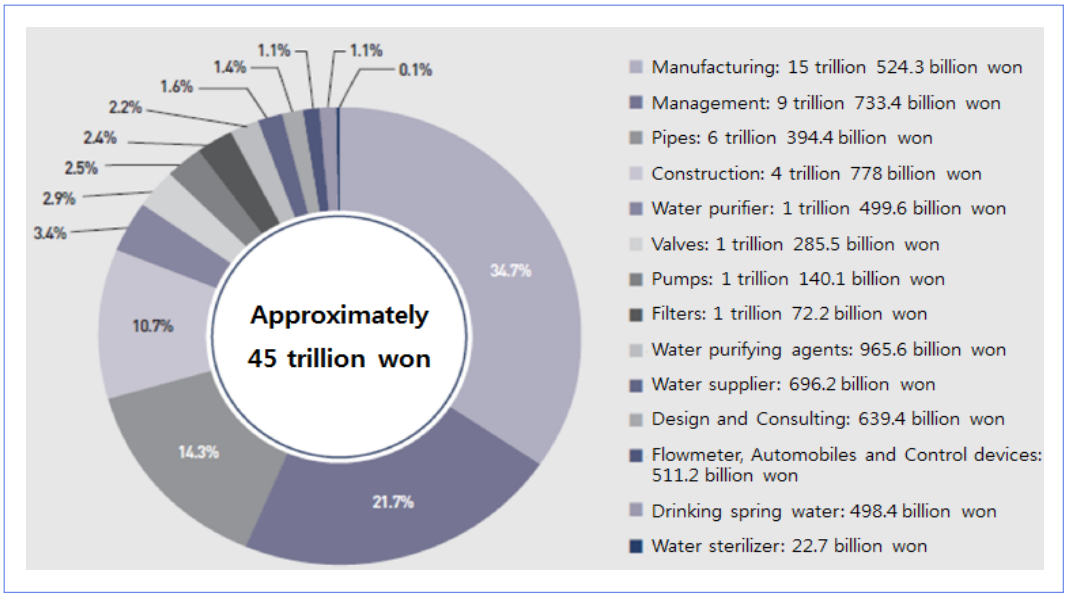
* Colombian sewerage distribution rate is statistically indicated by the pipeline connection rate, so simple comparison is meaningless. The distribution rate is compared here in reference to the sewage treatment rate of each department.

2. Water Industry

2.1. Current Status and Prospects of the Domestic Water Market in Korea

The domestic water industry in Korea is worth 45 trillion KRW as of 2014, and accounts for 3.01% of the total GDP (1,486 billion 793 million KRW). Manufacturing accounts for 34.7% with 15 trillion 524.3 billion KRW and the four major (water) industrial sectors (manufacturing, management, pipes, construction) account for 81.4% of the total water market. As the distribution rate of waterworks and sewerage (98.2% for waterworks, 91.6% for sewerage) increases, the domestic market is changing its focus from construction to maintenance.

Figure 21 | Market Scale of Domestic Water Industry by Field (%)



Source: Water Resources of Korea in Statistics (Ministry of Land, Infrastructure and Transport, 2016)

The scale of the domestic market is about 15 trillion KRW (2.7% of the world market, 1.3% of GDP) and 85% of this is waterworks and sewerage. There has been a trend toward transformation to a maintenance market from the earlier focus on construction, as the distribution rate of waterworks and sewerage (waterworks 98.2%, sewerage 91.6%) has increased.

In the case of waterworks (i.e., for drinking water supply), local governments and public enterprises lead the market in terms of management and receiving orders, making it a structure in which fostering major companies capable of gaining economies of scale (over 20% of the share) is nearly impossible. Private participation in the management market consists of 84% for wastewater and 55% for sewage, but is almost nonexistent for waterworks.

The equipment market, which includes pipes, valves, and films are in a growth trend both domestically and internationally, but the average rate of Korean participation in exports is only 4.5%, which falls short of that in the domestic manufacturing industry (19.9%). Even then, 95% consists of small- and medium-sized enterprises with less than 50 employees, leaving them active only in the domestic market. However, valves, pumps, and pipes have relatively higher export participation rates (11 - 19%) and the separation-film-based water treatment market has a high growth rate (20%), indicating strong potential for future growth.

The market for reuse and conservation of water is gradually expanding from areas that have secure economic feasibility and necessity, such as industrial complexes and military bases. The infrastructure for the management of water demand is being expanded in preparation for the future, via sewage reuse projects funded by the government and private investments, and the pilot project of investment agency services for water conservation at military bases.

2.1.1. Progress in National Water Industry Policies

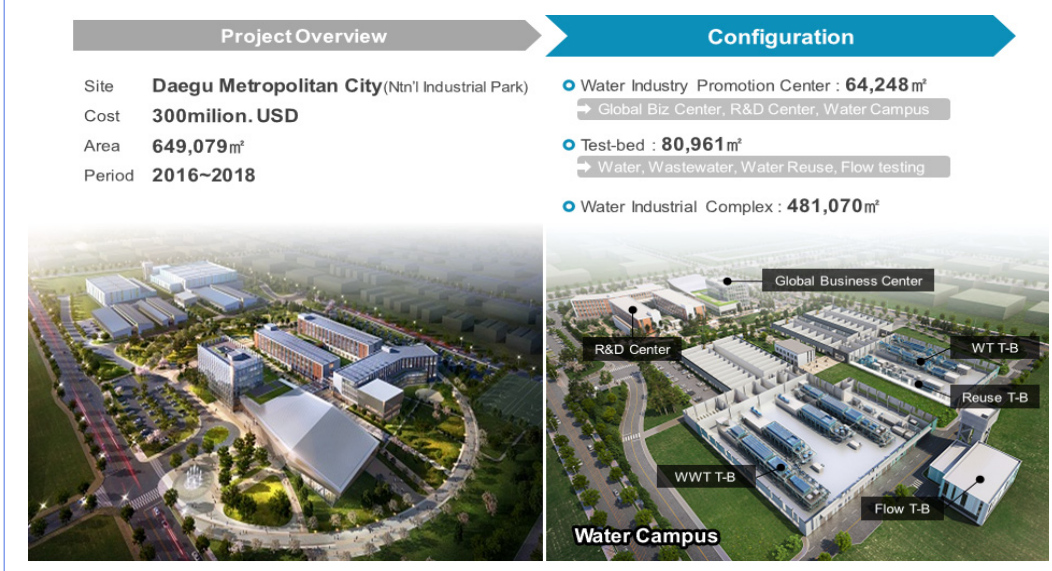
The Korean government soon acknowledged the importance of the water industry in driving the growth of the nation in the future. The program to foster the water industry was finalized and announced in February, 2006. This was followed by plans to consolidate the competitiveness of the water industry in September 2010, by plans to promote the water industry and vitalize overseas expansion in February 2012, and by a basic strategy for development of the water industry in September 2014. The government continuously strives to promote the water industry.

2.1.2. Water Industry Cluster Project

Domestic companies can fall behind in aspects such as competitiveness and commercialization of core technology, and total solutions require infrastructure and support for R&D that is difficult to acquire individually. Acknowledging the need to benchmark, Singapore entered the world market in a short period of time, and the Korean government aimed to establish a Water Industry Cluster from policies announced in 2010. Through this project, a support system was provided to Singapore, which consisted of a virtuous cycle that led from development and tests to commercialization of technologies.

The Water Industry Cluster was in progress for 4 years (2015 - 2018), with a total cost of 233.5 billion KRW of government expenditure. Water industry promotion facilities such as testing and research, verification facilities, and a global business center will be constructed at a site with the area of 649,000 m2, located inside the Daegu National Industrial Complex. This project aims to promote the water industry as the new driving force of growth. The core goal is to enhance technological competitiveness and support overseas expansion of domestic water companies by providing aid at all stages from R&D to commercialization.

Figure 22 | Overview and Configuration of Water Industry Cluster



Source: Water Resources of Korea in Statistics (Ministry of Land, Infra

The core goal is to support all steps from R&D to commercialization to enhance technical competitiveness and overseas expansion of domestic water enterprises.

Supporting the overseas expansion of the water industry has been the basis of all policies since the establishment of the first water industry promotion program in 2006, followed by ceaseless effort by the government. This project is based on the same values, and thus is expected to serve as priming for the Korean domestic water industry to enter the Colombian market.

The Korean government passed a new bill, the Special Act on the Water Industry Cluster, to provide legal grounds for the establishment and management of the water industry cluster in 2015. Based on the Special Act on the Water Industry Cluster, the Water Industry Promotion Center was newly established to take charge of the management of the cluster which was expected to lead to fostering of water companies. Also, the Water Industry Council is being run by a PPP to make the water industry a new growth engine, and to contribute to the national economy as well as providing foundations for the enhanced water welfare of the citizens.

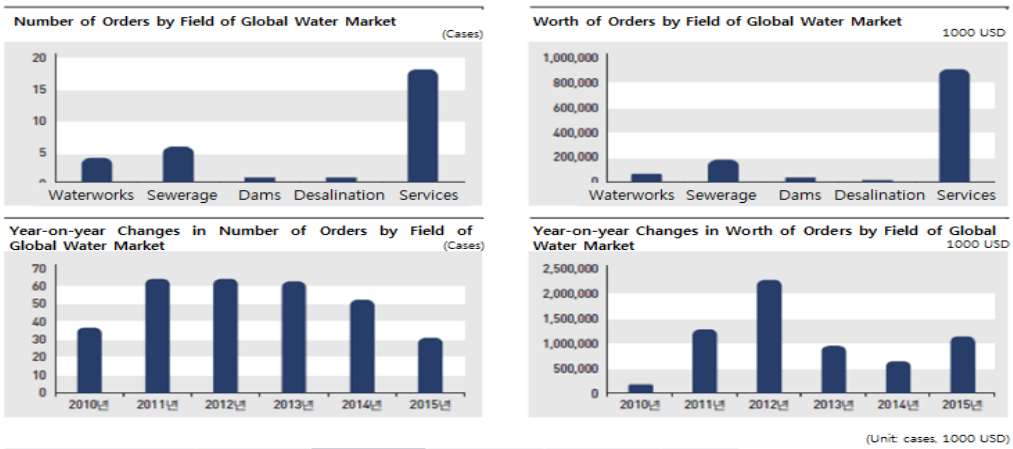
2.2. Overseas Expansion of Water Industry

The number of new orders to Korean domestic companies regarding construction and services related to the global water market was 31, worth 1,181,268,000 USD (including changes and joint projects). The field of sewerage engineering construction (civil engineering, sewerage, industrial facilities, environmental facilities, sewage treatment) received the most orders (six cases). Eighteen orders for water services were received, worth 888,440,000 USD. The number of new orders accumulated in 2010 - 2015 was 308, worth 6,623,577,000 USD.

The amount of orders regarding waterworks and sewerage is also increasing, but the competitiveness of the high value-added fields (original technology, tools and materials, etc.) is not as high, due to the focus on the construction-oriented business model. Most importantly, there has been no overseas performance reported in the field of water supply and wastewater treatment facility maintenance, which are key fields in the water industry.

The exports by domestic companies in 2015 were worth 1.65 trillion KRW according to the water industry statistics from KWWA (Korea Water and Wastewater Works Association), and manufacturing accounted for the largest portion (98.4%, or 1.62 trillion KRW). The statistical data regarding the domestic water industry is not unified; thus the scale and content differ by agency.

Figure 23 | Number and Worth of Orders by Field of Global Water Market



(Unit: cases, 1000 USD)

Categories	Total	Waterworks & Sewerage	Waterworks	Sewerage	Dams	Desalination	Services
No. of Orders (Case)	31	1	4	6	1	1	18
Worth of Orders (1000 USD)	1,181,268	10,879	53,720	176,506	41,771	9,952	888,440

Source: Water Resources of Korea in Statistics (Ministry of Land, Infrastructure, and Transport, 2016)

Table 25 | Water Industry Exports in 2015

Categories	Exports (1 million KRW)	Portion (%)
Manufacturing	1,624,217	98.42
Construction	25,800	1.56
Management	-	-
Design/Consulting	318	0.02
Total	1,650,335	100

Source: KWWA, Water industry statistics in 2015

2.3. Water Treatment Technology Status

The level of technology held by the Korean domestic water industry is at the level of 75 - 80% of developed nations in the fields of waterworks, sewerage, and seawater desalination (etc.), and 55 - 65% of the technology in cutting-edge fields. Competition at the global scale will only be possible when all the national resources are focused on nurturing such fields. An integrative management system of seven regions has been established and is managed for waterworks and has access to management and water quality analysis technologies at global standards.

Contracting-out is usual for sewerage (75%), but it is mainly focused on short-term contracts and small-scale enterprises; so there is a demand for competitive corporations with expertise.

The trends in technology development in the field of water purification have brought to a focus the importance of technology-intensive manufacturing and solutions since separation films, which are efficient for both treatment and space utilization, began replacing traditional water treatment methods. The technical innovation of professional manufacturers and the drastic increase of market demand towards multi-functional products has led to a 75% decline in the price of osmotic RO filters during the last decade, and halved the energy consumption compared to five years ago. These changes have promoted rapid expansion of the market. UV sterilization is growing fast in the field thanks to its effectiveness and low maintenance cost. Physical treatment comprising the processes of mixing, aggregation, precipitation, filtration, and chlorination was utilized in treating water before, but now is being replaced by the use of separation membranes in processes comprising precipitation, MF/UF filtration, and UV/ozone sterilization.

It is expected that future technologies involved in water purification treatment processes in demand will include innovations in material technology; water treatment chemistry; diagnosis, optimization, upgrading, and retrofitting; supervisory control and improved performance; integration; compaction; and bank and stream bed filtration. Advanced water purification processes will require the integration of UV, ozone, active carbon, membranes, etc..

The core technologies for the treatment of sewage and wastewater are those that enhance the quality of discharged water and produce reusable water, increase energy self-reliance and resource circulation, and provide ICT-linked treatment of sewage and wastewater. The technology to enhance the quality of discharged water and produce reusable water can be improved by focusing the investments in the IT-integrated Korea-style processes. The Korean technology to increase energy self-reliance and resource circulation exhibits weakness in IP marketability and competitiveness (compared to that of Japan) in the field of phosphorus/nitrogen withdrawal. ICT-linked treatment of sewage and wastewater requires continuous R&D in the fields of high level processing, automation, localization, and integration by introducing advanced domestic IT technology.

Technologies related to the circulation of water include industrial wastewater treatment, reduction of non-point pollution and desalinization, and a smart grid technology is to be proliferated for the integrative management of such technologies.

3. Study of PPP Cases in Korea

3.1. Regulations and Policies regarding PPP

3.1.1. Progress of Domestic PPP Business

Private investment businesses were allowed since 1968 according to the archives of the Economy Planning Board, but were not as actively promoted. President Kim Young-sam, who pursued a small government, wanted to build various SOC facilities with private capital during his term. This led to the enactment of the 「Act on Promotion of Private Investment to Social Overhead Capital Facilities」 in 1994, introducing private investment to the construction and management of infrastructures.

Immediately after the IMF financial crisis in the end of 1998, there was a great need for SOC businesses to stimulate the economy. However, the lack of funding was a problem, which led to an active attraction of private investments. The aforementioned Act was amended to the 「Act on Private Investment to Social Overhead Capital Facilities」, allowing more businesses to be implemented with private investments. This method introduced in 1999 is Minimum Revenue Guarantee (MRG), which caused numerous problems and negative attitudes toward private investment businesses. In Minimum Revenue Guarantee (MRG), the government guarantees the previously agreed minimum revenue when the actual revenue during the management of the facilities built by private investment is less than the revenue estimated in the validity test.

The re-amendment to 「Act on Private Investment to Infrastructure (hereafter 'Act on Private Investment')」 in 2005 introduced the lease (BTL) type private investment in addition to the previously existed profit (BTO) type private investment.

MRG was abolished in 2009 due to the immense expenditure caused to compensate for the losses. As of 2012, a total amount of 3.3 trillion won (national management business 2.9 trillion won, local government business 400 billion won) was paid for MRG and there were no more contracts that guaranteed minimal revenue after 2006. Certain contracts that were concluded before but not agreed went through dispute mediation procedures.

The government and authorities plan to reinforce efficient management through improving the system in order to respond with flexibility to fluctuating economic conditions. As the concerns are constantly raised regarding the financial burden aggravated according to the

expenses such as construction subsidies, minimal revenue guarantees, land acquisition costs and BTL government payments, the government follows the guideline for financial burdens from private investment businesses in order to prevent the exacerbation of financial integrity.

The development progresses classified by PIMAC pinpoint major changes of policies by each stage: emphasis on government-set businesses in phase 2, introduction of private proposals in phase 3, and introduction of lease-type (BTL) businesses in phase 4. The progression of private investment by each phase is illustrated in the following table.

Table 26 | Progression of Private Investment by Phase

Phase	Period	Characteristics
Phase 1	1968~1994	• Implementation of sporadic private investment businesses based on different laws (Road Law, Port Law, etc.)
Phase 2	1994~1998	• Attraction of private investment through clear and systematic procedures with the enactment of the 「Act on Promotion of Private Investment to Social Overhead Capital Facilities」 • Classified into type 1 facilities (BTO type) and type 2 facilities (BOO type) • Poor performance due to regulations and role evasion by the government in concerns regarding the immature circumstances and controversy about favoring →「Establishment of Comprehensive Plans to Attract Private Investment」 and amendment to 「Act on Private Investment to Social Overhead Capital Facilities」
Phase 3	1998~2004	• Active government support and role allocation for the vitalization of private investment • Abolished classification between type 1 and 2 facilities to promote diversification of business styles • Stimulation of private investments and business participation
Phase 4	2005~Now	• Enactment of the 「Act on Private Investment to Infrastructure」 • Introduction of lease-type(BTL) • Compulsory eligibility tests to private-proposed projects, etc. • Installment of the Dispute Mediation Committee • Public offices are included in facilities eligible for private investment in the amendment (prospective) in 2004

Source: KDI, Performance Analysis and Implications of Private Investment Businesses

3.1.2. Vitalization Policies for Private Investment

The Ministry of Strategy and Finance announced the basic directions and projects to revitalize the economy through promotion of private investments on 8 April 2015. It aimed to enhance attraction of investment through the introduction of creative business styles, enhance the efficiency of project initiation by simplifying private investment procedures, and improving negative images through public-private partnership.

Table 27 | Six Tasks for Vitalization of Private Investment

Six Tasks	Detailed contents
1. Introduction of creative business styles	① Introduce BTO-rs, BTO-a business styles
2. Drastic alleviation of limiting factors of private investment	① Exclude incorporating affiliates according to the Fair Trade Act ② Alleviate burdens for private proposals ③ Introduce Fast Track procedures
3. Increased range of target facilities	① Introduce preferential review of private investments ② Increase range of targets including public offices
4. Increased government support	① Vitalize subsidiary enterprises ② Increase pre-compensation of land ③ Increase guarantee from industrial infrastructure credit guarantee fund ④ Support tax ⑤ Support swift settlement of conflicts ⑥ Enhance expertise of public officers in charge of private investment ⑦ Reinforce supporting function of KDI PIMAC
5. Reduction of previous MRG	① Reduce MRG of previous private investment projects
6. Prompt implementation of business	① Promptly implement ongoing private investment projects

3.2. Types of PPP

PPPs can be classified into various types according to the attribution of construction, ownership, and operating rights of the target infrastructure to the government or to the private enterprises that invested. This is officially stated in Article 4 of the Act on Private Investment regarding the progress types of private investment business. According to the respective laws, there are BTO, BTL, BOT, and BTO-rs / BTO-a, announced by the Ministry of Strategy and Finances.

Table 28 | Progression in the Types of Private Investment Business

Type	Description	Type	Description
BTO	Build-Transfer-Operate	BTO-rs	BTO-risk sharing
BTL	Build-Transfer-Lease	BTO-a	BTO-adjusted
BOT	Build-Operate-Transfer	RTO	Rehabilitate-Transfer-Operate
BOO	Build-Own-Operate	ROT	Rehabilitate-Operate-Transfer
BTO+BTL	Build-Transfer-Operate	ROO	Rehabilitate-Own-Operate
BLT	Build-Lease-Transfer	RTL	Rehabilitate-Transfer-Lease

The type of progression is either profit or lease according to the type of facilities targeted for the investment business, and the risks and the rates of return differ accordingly. The following table illustrates the comparison between the BTO and BTL types.

BTO-rs (risk sharing-type) and BTO-a (profit and loss sharing-type) types were proposed as new business styles, as part of the policy of the Ministry of Strategy and Finance to promote private investment in April 2015. The aim of the proposal was to reduce the rate of return through sharing risks between the government and private firms; thereby minimizing tolls and monetary support. Table 30 illustrates the comparison between the BTO type and BTO-rs / BTO-a types.

Table 29 | Comparison between BTO and BTL

Type of Process	BTO, BOT, BOO, etc.	BTL
Classification	Profit-type private investment business	Lease-type private investment business
Recovery of investment	Fees paid by users	Rents paid by government
Major facilities	Roads, railroads, ports, etc.	Schools, military residences, sewerages, cultural or welfare facilities, etc.
Business risk	Relatively high (Rate of return fluctuates depending on the demand)	Relatively low
Rate of return	Relatively high	Relatively low

Table 30 | Comparison between BTO, BTO-rs, and BTO-a Business Styles

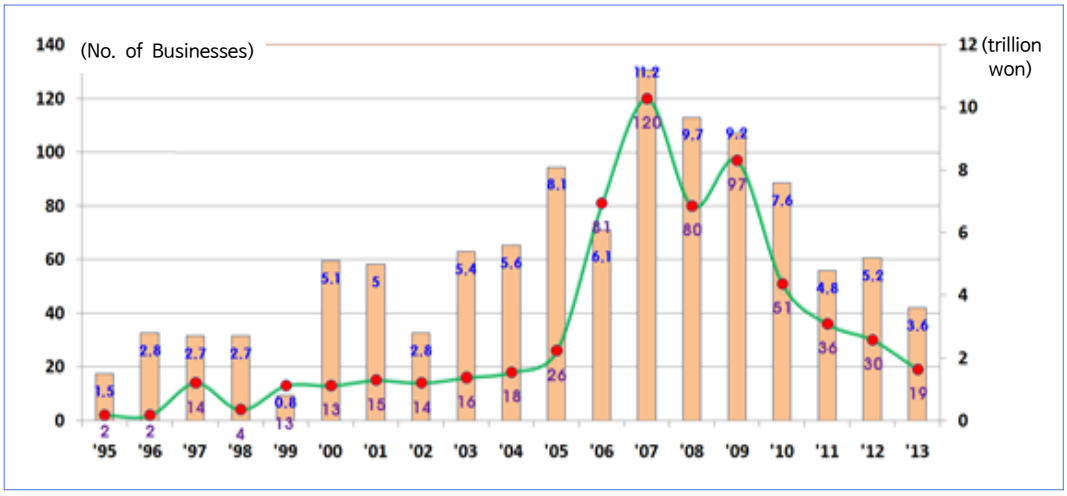
Categories		BTO	BTO-rs	BTO-a
Private risk		High	Medium	Low
Burden of Profit and Loss	Loss	100% Private responsibility	Government and private firms share by pre-determined ratio	Private firm first invests without guarantee Government provides funding when the amount of principal is lost or fail to meet minimum management expenses
	Profit	100% Private responsibility	Government and private firms share by pre-determined ratio	Government and private firms share by pre-determined ratio
Conservation by government		None	Investment costs and management expenses allocated to government	70% of Private investment costs: Principal and interest, 30% of interest costs, management expenses (30% of principal is not conserved)
Rate of return in 2014 (current)		7 - 8%	5 - 6%	4 - 5%
Applicable business (example)		Roads, ports, etc.	Railroads, light rails	Environmental business
Fees		Agreed fee + price	Agreed fee + price	Similar level as public enterprises

3.3. Domestic PPP Trend

3.3.1. Business Size and Number of Domestic PPP Businesses

Approximately 100 trillion KRW (662 PPP projects as of 2014) was invested over the last two decades and contributed to developing the national economy by reducing distribution costs and alleviating traffic congestion. As in the cases of foreign private investment, intensive investments made before and after the financial crises in 1997 and 2008 played a significant role in restoring the economy.

Figure 24 | Size and Number of Private Investments and Businesses



3.3.2. Private Investment Businesses by Types of Progression

Comparing the two major types of progression, profit-type and lease-type, the latter exceeded the former by two-fold in the number of businesses, but 71.5% of the total amount of investments made went to profit-type.

Table 31 | Private Investment Businesses by Types of Progression

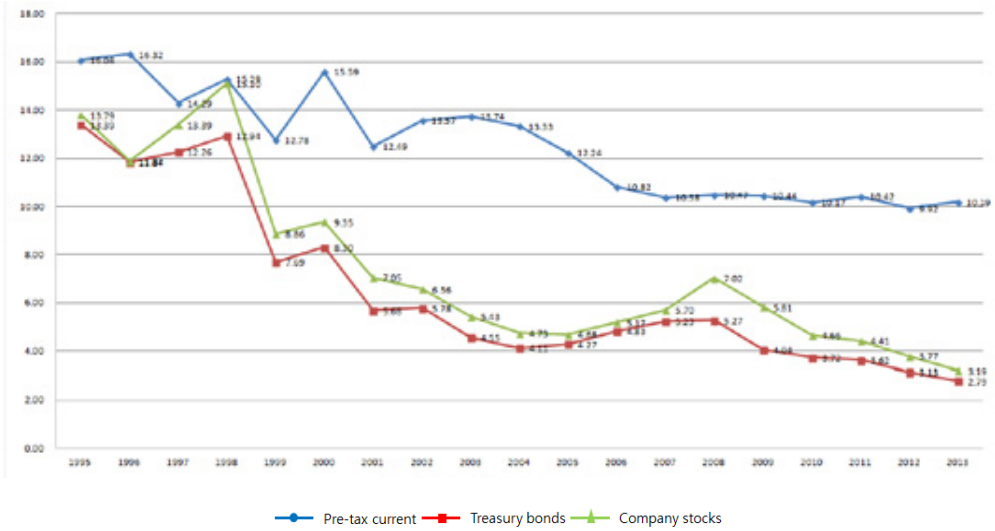
(Unit: 100 million won)

Types		No. of Business	Proportion of No. of Business	Total Business Expenses	Total Investments	Proportion of Total Investments	Average Investments
Profit-type	BTO	205	31.78%	499,708	661,936	69.49%	3,229
	BOO	7	1.09%	11,007	14,388	1.51%	2,055
	BOT	4	0.62%	5,510	6,580	0.69%	1,645
	Subtotal	216	33.49%	516,225	682,904	71.69%	2,310
Lease-type		BTL	66.51%	236,200	269,710	28.31%	629
Total		645	100.00%	752,425	952,614	100.00%	1,477

Source: KDI, Performance Analysis and Implications of Private Investment Businesses

3.3.3. Rate of Return Trend by Types of Progression

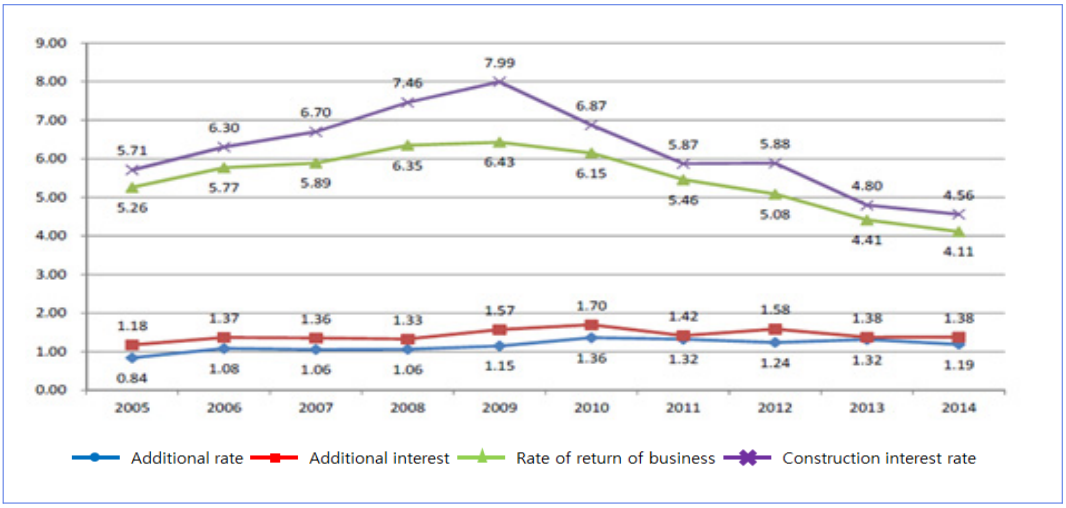
Figure 25 | Rate of Return Trend of Profit-type (BTO) Private Investment Businesses



A trend of downward stabilization was seen with yearly pre-tax current rate of return of BTO businesses, and of interest rates of treasury bonds and company stocks after 2000, when private investment businesses became active. After 2008, the interest rates of treasury bonds and company stocks fell, but the pre-tax current rate-of-return was stable. Due to the financial crisis in 2008, the interest rate of company stocks drastically increased compared to the previous year and experienced a bigger gap in the spread of the interest rate of treasury bonds, but the rate of return of BTO businesses remained unchanged.

The rate-of-return trend of lease-type (BTL) private investment businesses is determined by the offers made during competition between individual entrepreneurs in consideration of factors like the fund-raising expense and degree of business risk. It is calculated by applying an additional rate (α) to the interest of five-year government bonds, which reflects the risk premium for long-term investment, construction, and management.

Figure 26 | Rate of Return Trend of Lease-type (BTL) Private Investment Businesses



3.3.4. Private Investment Business by Main Agents

The main agents can be divided into the state, subsidized local governments, metropolitan governments, and basic local governments. The amount of accumulated investments of the businesses implemented by the state comprises 61% of the total investment, which is about 105.6 billion KRW. The number of businesses implemented by the metropolitan and basic local governments was more than half the total number of businesses, but the amount of investment took up only 15% of the total investments.

Table 32 | Private Investment Business by Main Agents

(Unit: 100 million won)

Main Agents		No. of Business	Proportion of No. of Business	Total Business Expenses	Total Investments	Proportion of Total Investments	Average Investments
State		169	26.20%	433,499	581,056	61.00%	3,438
Subsidized local governments		163	25.27%	178,388	228,085	23.94%	1,399
Local Governments	Metropolitan	207	32.09%	85,848	94,104	9.88%	455
	Basic	106	16.43%	54,689	49,369	5.18%	466
	Subtotal	313	48.53%	140,537	143,473	15.06%	458
Total		645	100.00%	752,425	952,614	100.00%	1,477

Source: KDI, Performance Analysis and Implications of Private Investment Businesses

3.3.5. Private Investment Business by Fields

Table 33 | Private Investment Business by Fields

(Unit: 100 million won)

Field	No. of Business	Proportion of No. of Business	Total Investments	Proportion of Total Investments	Average Investments
Education	223	33.7%	97,401	9.8%	437
Environment	176	26.6%	128,742	13.0%	731
Roads	84	12.7%	423,894	42.6%	5,046
National Defense	71	10.7%	55,833	5.6%	786
Culture and Tourism	41	6.2%	19,079	1.9%	465
Ports	18	2.7%	69,454	7.0%	3,859
Railroads	13	2.0%	173,121	17.4%	13,317
Airports	13	2.0%	7,104	0.7%	546
Welfare	12	1.8%	3,490	0.4%	291
Distribution	6	0.9%	12,605	1.3%	2,101
Information and Communications	5	0.8%	3,398	0.3%	680
Total	662	100.0%	994,121	100.0%	1,502

Source: KDI, 2014 KDI PIMAC Annual Report

When comparing private investment businesses by fields, education takes up the highest portion (36.6%) with 223 businesses, followed by the environment (26.6%) with 176 businesses. In terms of investment, the amount of accumulated investments in roads was 42 trillion KRW from 3894 businesses. This accounted for 42.6% of the total investments made, and the average investment per business was 504.6 billion won. Only 13 projects were implemented in railroads, but the total amount of investments reached 17.3121 trillion KRW, achieving an extraordinary level of average investment per business, which was 1.3317 trillion KRW.

The following table (Table 34 shows the official data regarding yearly number of projects by progression of private investment businesses calculated by PIMAC.

Table 34 | Implementation of Private Investment Businesses by Year

Year	Eligibility test/ Private proposal review / Validity analysis						Project Basic plans (provisional), Notice of Third party proposal (provisional) Review, etc.	Project plan evaluation	Negotiation for conclusion of enforcement agreement	Review and advice for Agreement (provisional)	Negotiation for fund re-raising and review in advance	Event and Education	Dispute Mediation review	Public investment policy forum	Total
	Eligibility test	Proposal review	Validity analysis (BTL)	Validity analysis (BTO)	Demand Prediction Reinvestigation	Eligibility re-test									
1999		5	4				7	1	3			4			24
2000		23	8				7	2	32			5			77
2001		19	10				9	8	23			3			72
2002		22	0				7	7	25			5			66
2003		39	4				12	0	29			5			89
2004		15	4				11	7	20			8			65
2005	4	11					48	16	6	41		20			146
2006	1	12					57	8	8	117		27			230
2007	12	11					62	17	6	149	4	24			285
2008	10	15					42	5	8	178	12	25			295
2009	25	14	68				42	1	4	130	14	22		1	321
2010	5	13	17				35	7	4	110	9	15		4	219
2011	3	10	14				18	4	3	115	16	19		6	208
2012	5	5	20				14	2	3	193	22	32	3	6	305
2013	2	7	15	1			12			160	28	38	1	2	265
2014	2	5	12	2	2	2	11		4	212	62	22	2	4	342

Source: KDI, PIMAC Homepage

3.4. Successful Cases

3.4.1. Private Investment Project for Sewage Treatment Facilities in Yongin

This project was for the installment of 12 new sewage treatment facilities in response to the sharp influx of population and trend of urbanization of Yongin. It also included the unified operation of 15 existing treatment plants, including two for sewage and one for excreta. It was the biggest project implemented with a single contract among domestic BTO businesses, intended to treat 260,000 tons a day (80% of the total sewage produced in Yongin). The project used the biological nitrogen (N) - phosphorus (P) elimination process (5-Stage BNR method, SBR method, MBR method) and was run for 20 years after construction over 48 months, with total expenses of 609.7 million KRW.

Table 35 | 12 Sewage Treatment Plants in Yongin

No	Plant	Process Method	Capacity (㎥/day)	Address
1	Suji	5-Stage BNR	110,000	1003-235, Jukjeon2-dong, Suji-gu
2	Sanghyun	5-Stage BNR	13,000	612-1, Sanghyeon-dong, Suji-gu
3	Mohyeon	MBR	16,000	41-13, Ilsan-ri, Mohyeon-myeon, Cheoin-gu
4	Gomae	SBR	6,200	48, Nongseo-dong, Giheung-gu
5	Seocheon	SBR	7,800	433, Seocheon-dong, Giheung-gu
6	Cheonri	SBR	9,000	1068, Deokseong-ri, Idong-myeon, Cheoin-gu
7	Songjeon	SBR	2,300	445, Songjeon-ri, Idong-myeon, Cheoin-gu
8	Namsa	SBR	2,000	541-5, Bongmyeong-ri, Namsa-myeon, Cheoin-gu
9	Dokseong	SBR	430	588-3, Dokseong-ri, Wonsam-myeon, Cheoin-gu
10	Baegam	MBR	3,000	67, Geunsam-ri, Baegam-myeon, Cheoin-gu
11	Chugye	MBR	1,000	4-1, Chugye-ri, Yangji-myeon, Cheoin-gu
12	Dongbu	MBR	800	282, Nam-dong, Cheoin-gu

Table 36 | Progress of Private Investment Project for Sewage Treatment Facilities in Yongin

2002.05.01: Basic plans for maintenance of sewerage in Yongin approved (Ministry of Environment)

2002.05.17: Private proposal submitted (Provisional name, Yongin Clean Water Co., Ltd.)

2002.09.19: Review of proposal contents requested (Yongin → Korea Research Institute for Human Settlements)

2003.01.10: Results of contents review delivered (Korea Research Institute for Human Settlements → Yongin)

2003.01.16: Determined facilities for city plans (reorganization)

2003.03.28: Deliberation and decision of Yongin Private Investment Business Commission (Approved)

2003.12.26: Notified the decision for private investment business (Ministry of Planning & Budget, Yongin)

2003.12.31: Notice for third party suggestions for private investment business (Yongin Official Notice no. 2003-1786)

2004.04.29: Accepted suggestions for private investment business (Yongin Clean Water Co., Ltd., Yongin STP Co., Ltd.)

2004.05.21: Completed evaluation of business proposal (Korea Research Institute for Human Settlements)

2004.05.25: Designated subject of negotiation (First priority: Yongin Clean Water Co., Ltd., Second priority: Yongin STP Co., Ltd.)

2004.06.09: Request negotiation (Yongin → Korea Research Institute for Human Settlements)

2004.06.22~12.08: Negotiation (Private Infrastructure Investment Center of Korea, Korea Research Institute for Human Settlements)

2004.12.17: Deliberation and decision of Yongin Private Investment Business Commission regarding the enforcement agreement (provisional)

2005.01.14: Concluded enforcement agreement (Yongin, Yongin Clean Water Co., Ltd.)

2005.02.11: (Suji) Make available the first draft of the environmental impact statement to public

2005.02.22: (Suji) Hold briefing for residents regarding the first draft of the environmental impact statement

2005.03.14: Request consultation for designs and discuss budgets in advance (Yongin → Han River Water Shed Environmental Management Office)

2005.04.01: Make available for public the plans for compensation and resettlement

2005.04.27: Request consultation for design (Yongin → Han River Water Shed Environmental Management Office)

2005.05.05: Prior environmental review (Songjeon, Mohyeon, Namsa, Cheonri, Baekam) discussion complete

2005.05.17: Select land compensation valuation agency and conduct valuation

2005.06.21: Notify results of design consult (Han River Water Shed Environmental Management Office → Yongin)

2005.06.22: Reply discussed opinions regarding environment impact statement (final) (Han River Water Shed Environmental Management Office → Yongin)

2005.06.29: Discuss compensation for loss (1st phase)

2005.11.08: Approve enforcement plans (Yongin Official Notice no. 2005-375)

2005.11.25: Notice decision for land expropriation (Yongin Official Notice no. 2005-1188)

2005.12.27: Begin construction

2008.07.00: Operate facilities

2009.03.31: Hold opening ceremony for Suji Respia

2010.12.00: Complete construction of 12 sewage treatment plants and community facilities

In order to drastically increase the sewage treatment capacity in response to the constant increase of population, simultaneous construction of sewage treatment plants in various places was inevitable. The difficulty in securing the budget was resolved efficiently in time with the private investments. Mohyeon and Dongbu sewage treatment plants were not included in the government's comprehensive plan for water management; thus, the construction period was uncertain. Even so, the work proceeded with the support of private investment.

Samsung Engineering was able to utilize membrane technology to reduce management costs and improve water quality. They also applied the 'PADDO' system, which is a patented technology for sophisticated water treatment, to reduce chemicals used in treating the water but still minimize nitrogen and phosphorus, which cause the eutrophication of rivers. The PADDO system is an original technology developed by Samsung Engineering, which allows efficient and perfect processing by dividing the reactants into five phases. PADDO stands for the five phases, each letter the first from the name of each group.

P: Pre-Anoxic, A: Anaerobic, D: Denitrifying 1, D: Denitrifying 2, O: Oxic

Not only did it improve the water quality and reduce treatment costs, but also restored the water quality to under 7 ppm, which was a much more stringent level than the standards provided by the city of Yongin. Furthermore, it supplied 30,000 tons of water a day to Tancheon and Seongbokcheon, which flow into the nearby waters of the Han River, to prevent drying of the streams and thus allowing recycling of water resources and preservation of the local ecosystem.

An official from Yongin mentioned that they were able to reduce the management cost by a considerable amount through unified remote management of the sewage treatment plants, by entrusting the process to a private operator. They were able to benefit all the local governments, residents, and the company by installing certain sewage treatment plants underground and establishing community facilities such as sports facilities and parks on the ground surface. It was awarded the first place in 'Designs of East Asia and Pacific Region' among the Project Innovation Awards offered by the International Water Association (IWA) in June 2008.

3.4.2. Private Investment Project for Treated Wastewater Reuse Facilities in Pohang

This project was the first to reuse treated wastewater and receive support from the Ministry of Environment. The aim was to treat wastewater passed from the treatment plants to the

Hyeongsan River and supply it to the POSCO national industrial complex and the Pohang steel industrial complex. This is the largest private investment project to reuse treated wastewater and, it supplies 100,000 tons of industrial water per day.

Table 37 | Outline of the Private Investment Project for Treated Wastewater Reuse Facilities in Pohang

Categories	Contents
Location	Within Ilwon Pohang Sewage Treatment Plant in 125, Sangdo-dong, Nam-gu, Pohang-si
Expenditure	Total expenditure: 125.8 million won (unchanged price by 30 April 2009, excluding compensations) - 68 million won from government funds, 7.5 million won from local funds, 50.3 million won from private funds
Business type	BTO (Build-Transfer-Operate)
Main agent	P-Waters Co., Ltd. (Lotte Construction and eight other companies)
Initial investor	KB Asset Management and seven other companies
Constructor	Lotte (40%), Daewoo (25%), Daelim (15%), three local companies (20%)
Construction period	2012.02.01 - 2014.07.31 (30 months, including 3 months of trial)
Operation period	2014.08.01 - 2034.07.31. (20 years)
Facility size	Capacity: Industrial water 100,000㎥/day, Supply pipes : 11.71 km
Average sewage influx	155,550 ㎥/day - minimum 126,880 ㎥/day, maximum 171,443 ㎥/day
Treatment type	Reuse facility: pre-treatment separation membrane + reverse osmotic facilities (R/O) Condensed water treatment facilities: filtering through biological membrane
Treatment process	Advanced treatment process (Bio-SAC Process) + UV sterilization facilities
Treatment method	MF + R/O

Table 38 | Supply by Demand

(Unit:㎥/day)

Category	POSCO	Purification Plant in Industrial Complex	POSCO Steel Sheet	Dongguk Industries	Total
Planned supply	80,000	13,000	1,000	1,000	95,000
Actual supply	82,000	8,800	850	800	92,450

Source: Performance of August - December 2014

Figure 27 | Distribution diagram for Treatment of Wastewater Reuse Facilities in Pohang

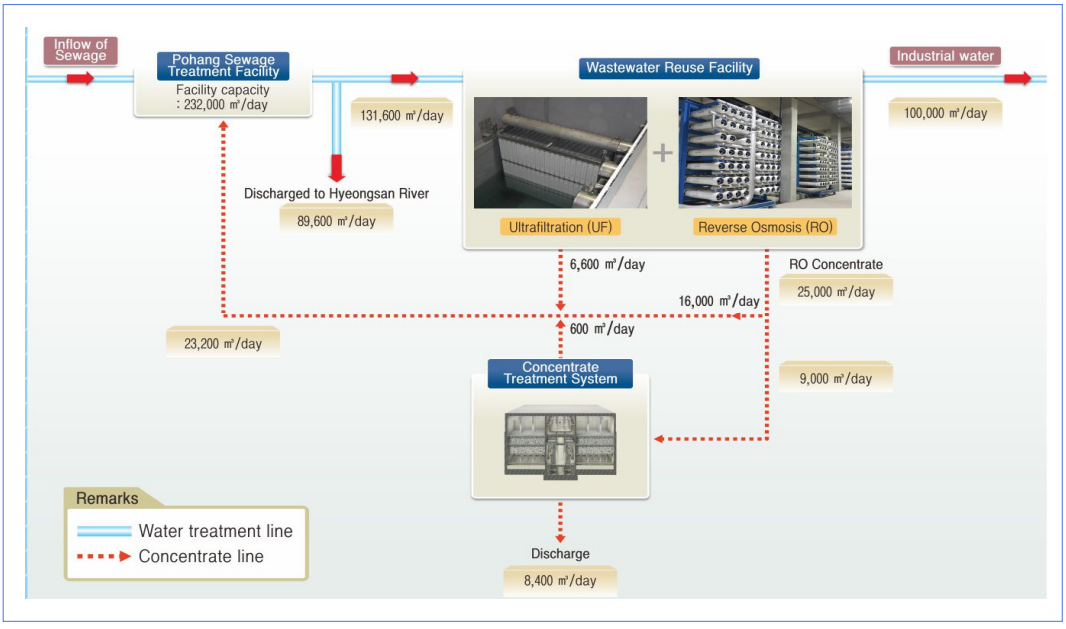


Figure 28 | Panoramic view of Wastewater Reuse Facilities in Pohang

Figure 29 | Wastewater Reuse Facilities in Pohang

UF Pre-treatment separation membrane

RO facilities

Reused water supplying facilities

PR room

Table 39 | Progress of Private Investment Projects regarding Wastewater Reuse Facilities in Pohang

2008. 03. 00: Discussion with Ministry of Environment regarding wastewater reuse facilities
2008. 08. 06: Conclude MOU of private investment business
2009. 02. 00: Request review to PIMAC
2009. 06. 16: Submit initial proposal of private investment
2009. 12. 00: Pass eligibility test
2010. 05. 00: Pass deliberation from the Private Investment Business Commission
2010. 05. 27: Notice for third party proposals (Pohang Official Notice no. 2010-544)
2010. 07. 15: Submit amendment proposals for private investments
2010. 07. 29: Designate preferred subject of negotiation (Pohang)
2011. 03. 31: Complete negotiation (Begin 2010. 08. 12)
2011. 07. 20: Complete deliberation from central commission for private investment regarding enforcement agreement (provisional)
2011. 08. 18: Conclude enforcement agreement and designate project operator
2011. 08. 19: Establish SPC corporate (P-Waters Co., Ltd.)
2011. 08. 24: Conclude enforcement agreement
2011. 12. 06: Begin construction
2011. 12. 16: Conclude subcontract
2011. 12. 29: Conclude financial contract
2011. 12. 30: Approval of installing reuse facilities (Gyeongsangbuk-do)
2012. 01. 17: Approval and notification of enforcement agreement
2012. 02. 01: Begin construction (period of 30 months)
2012. 10. 06: Begin construction of supply pipes for industrial water
2013. 01. 31: Complete construction of pilot facilities
2014. 05. 01: Initiate trial
2014. 07. 31: Complete construction
2014. 08. 01: Begin management (period of 20 years)

There were many cities and counties attempting to implement wastewater reuse projects by 2011, but many suffered problems related to a lack of economic feasibility and demand. Thus, this was the first and only case approved as a wastewater reuse facility.

The counter (reverse)-osmosis (R/O) method is widely used in many nations, including as Singapore, Kuwait, and Israel; where water resources are short. It produces drinking water by processing seawater and is considered the optimal water treatment method for facilities producing industrial water for the steel industry as it completely removes inorganic salts and salinity. For this feature, it was applied to the facilities in this project.

Of the water released into the Hyeongsan River from the sewage treatment plants in Pohang, 50% (100,000 tons per day), was reused as industrial water. This amount equals that

impounded behind the three Angye dams in Gyeongju combined. This approach allowed the securing of new water resources without constructing dams in processes that require high cost, and involve civil complaints and long construction periods. (The benefit from avoiding the use of the dams to provide 300,000 t/d was 270 million KRW).

Pohang is known to suffer shortages of rain and water. Through this project, it was possible to redirect 100,000 tons of dam water that was previously used for industrial purposes, to non-industrial purposes, stably resolving the chronic water shortage problems of the region. (The effect of securing the replacement of the water supply source was the reduction in the cost of the original water by 15.5 billion KRW/year).

This project resolved the water shortage in POSCO and the steel industrial complexes, allowed a stable supply of industrial water without fluctuation despite drastic climate changes such as draughts, and provided treated water at cheaper prices. This contributed to the price competitiveness of the companies residing in the steel industrial complex. As of 2014, when the construction was complete, the costs for water use was set at 500 won per ton, and the fees for the sewerage system was also reduced by 65%.

By supplying treated wastewater as industrial water, part of the profit was included in the profit of the city of Pohang, contributing to improvement of the city finances. It also enhanced the image of Pohang as an environmental city and its eco-friendly characteristics by advertising the reuse of wastewater in the 7th International Water Forum in 2015. The government's water industry promotion policies and low-carbon green-development policies were well promoted through the efficient use of water resources.

3.5. Cases of Failure

3.5.1 Gwangjeok (Gwangbaek) Sewerage Facilities in Yangju

This project, including the installation of public sewage treatment facilities and maintenance of the sewage pipes in the Gwangjeok (Gwangbaek) area in Yangju, was implemented in 2006, to be completed in 2011 with a budget of 106.4 billion KRW. According to the enforcement agreement, the Gwangjeok Sewerage Project (BTO) was planned to be funded with 49.741 billion KRW of financial support, including 25.25 billion KRW borne by causers, and 1.915 billion KRW of private investment. The terms stated that the private entrepreneur would cover 13.7 billion KRW of the 70 billion KRW of the initial construction cost and receive 5.7 billion KRW every year for the next 20 years from the city, of which the total amount would be 113.8 billion KRW.

Hanwha E & C had completed the basic design of the Gwangjeok sewage treatment plant in December 2006, the discussion on the support of the Ministry of Environment in September 2008, and had concluded an enforcement agreement with the city of Yangju in May 2010. However, prior to concluding the agreement, it was pointed out that the terms were in favor of the company as the project was implemented without careful examination of the losses that could occur when the project was based on finances or private investments. Following the criticism that bigger loss was expected under these terms than in case of typical financial business, a full review was requested to the accounting firm and the results indicated a 180.4 billion KRW loss to the city considering the price fluctuation rate for the next 20 years. The city of Yangju decided to terminate the enforcement agreement following the service analysis that 139.7 billion KRW of the budget could be saved when the project was abandoned.

The Yangju Environmental Co., Ltd. filed a lawsuit against the city of Yangju when it canceled the designation of the project operator on 28 November 2011, but lost when the first administrative department of the Uijeongbu District Court concluded to dismiss the contract on the sewage treatment plant in January 2013. Hanwha E & C, Yangju Environmental Co., Ltd. prevailed in a subsequent lawsuit against the city of Yangju regarding the 'cancellation of the cancellation of the project operator designation'. As for the reason of dismissal, the city of Yangju argued that a) the project operating corporation was not established in accordance with the plan submitted at the evaluation stage, b) documents, including the loan agreement, were not submitted when applying for the project operation, c) guaranteed securities for the project operation were submitted after the submission period, d) the investor was changed without approval from the competent authorities when the corporation was established to apply for the project operation, and so on. However, the court ruled that the city of Yangju contributed to termination of the contract.

According to the Board of Audit and Inspection, it was revealed that the government had unilaterally cancelled the agreement because of the concerns regarding the financial loss after it had designated a private operator. This decision was made against the lack of economic feasibility indicated by the cost benefit of 0.261 when operated as a private investment project. For this reason, a budget of 251 million KRW was spent for compensation and 2.2166 billion KRW was wasted as compensation for the land. Yangju City, the main agent of the project implementation, will not be able to avoid the criticism that it has wasted billions of won in the budget by implementing the business without thorough examination.

3.5.2. Advanced Water Purification Facilities in Daejeon

Table 40 | Project Outline for the Modernization of Advanced Water Treatment in Daejeon Metropolitan City

Categories	Contents
Project Name	Modernization of Advanced Water Treatment in Daejeon Metropolitan City
Project Location	Songchon water purification plant and Wolpyeong water purification plant of the waterworks system of Daejeon Metropolitan City
Project Type	BTO (Build-Transfer-Operate)
Project Operator	Daejeon Pureunmul Co., Ltd. (provisional name) (POSCO E&C, etc.)
Total Project Cost	167.3 billion KRW (50.2 billion KRW from Daejeon city, 117.1 billion KRW from private investors)
Period of Project	2018 - 2028
Period of Management	25 years (Yearly management cost covered by Daejeon city : 4.5 billion KRW)
Scale of Facility	Installment of the Advanced Water Treatment Facilities: 3 plants, 0.5 million tons (secondary treatment of 0.1 million tons in Songchon water purification plant, primary and secondary treatment of 0.4 million tons in Wolpyeong water purification plant) Construction of Waterways: Joongri Water Harvesting Plant, Samjeong Water Harvesting Plant 8.3 km

As a project proposed from the private sector, 'Daejeon Pureunmul Co., Ltd. (provisional name)' was submitted to the city of Daejeon and the PIMAC review was completed in August 2015. The advanced water purification facility is equipped with advanced filtration technology in the existing water purification process to remove the unique taste and odor of tap water and remove microorganisms and trace organic substances such as by-products of sterilization.

Due to the deteriorated water quality of Daechung Lake, the water source, the existing water purification methods are considered inadequate to control the harmful substances. Moreover, the expansion of advanced water purification facilities was deemed necessary because the trihalomethanes (THMs), an organic compound determined to be an actual carcinogen, have been increasing every year. Acknowledging the water quality deterioration of Daechung Lake, Daejeon City was also planning to gradually implement the project considering the financial situation. In fact, Daejeon City has completed the construction of an advanced water purification plant capable of processing 0.1 million tons of water at the Songchon water

purification plant with funding from the national and city government. It is producing 0.1 million t/d of highly purified water.

This is the first time in Korea that an advanced water purification modernization project has been implemented using private investment, but the extreme objections of city councilors and citizens due to the controversy regarding privatization is preventing the project from being further implemented. Opponents argued that it should be considered privatization when tap water, a highly public good, is privately operated for 25 years and that raising the water tax would be inevitable in this case to guarantee profit. On 5 September 2016, the Review Committee for the Private Investment Projects held a closed meeting to review the feasibility of the private investment project on the 'Modernization of Advanced Water Treatment in Daejeon City' but failed to draw a conclusion. On 20 September 2016, at the 227th plenary session of the Daejeon City Council, 21 of the 22 councilors were present and unanimously approved the resolution regarding the 'Termination of the Private Investment Project on the Modernization of Advanced Water Treatment in Daejeon Metropolitan City'.

Although the project was implemented through BTO rather than BOO, a privatized type of business, the fact that the operation rights would belong to a private corporation for 25 years, that Daejeon City's share of the yearly management costs was excessive and that a private operator was getting involved in the waterworks, a necessity, provoked strong resistance among the people.

3.6. Proposals

According to data from KDI PIMAC, the majority of the PPPs in Korea are implemented using BTO (profit type) and BTL (lease type), and the review process and evaluation methods for such are the most advanced.

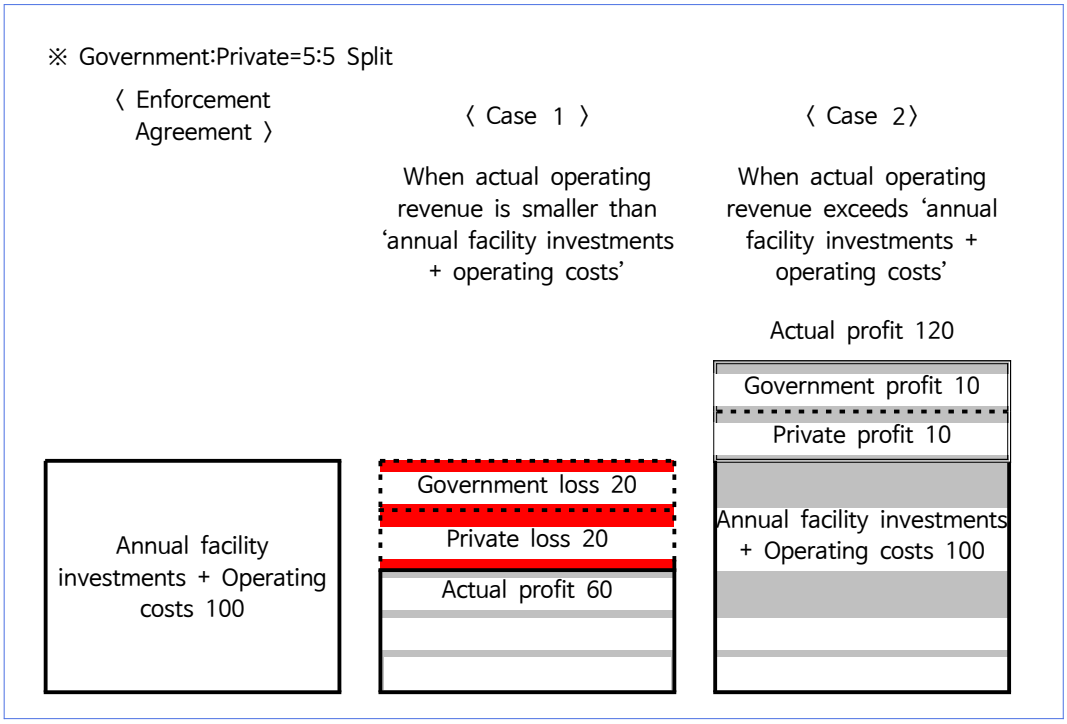
Because the main purpose of the PPP is to ensure that the government and the private sector can efficiently and timely share the technologies and budgets necessary for building a social overhead capital, the amount of the burden shared by the government and private sector is more affected by the contract between the two, rather than the actual type of PPP.

The government and the private sector will determine the cost, risk, and profit / loss sharing of the costs arising from each stage of the project, including construction cost, facility operation cost, and facility investment cost. In April 2015, two new PPP schemes (BTO-rs and BTO-a) were introduced, which incorporated some of these costs and risks into public-private cooperation projects and institutionalized it.

3.6.1. BTO-rs, Build Transfer Operate-risk sharing, Risk sharing type

The government shares the risks from the project implementation to reduce the risks of the private sector, leading to an overall decrease of profit rates and fees.

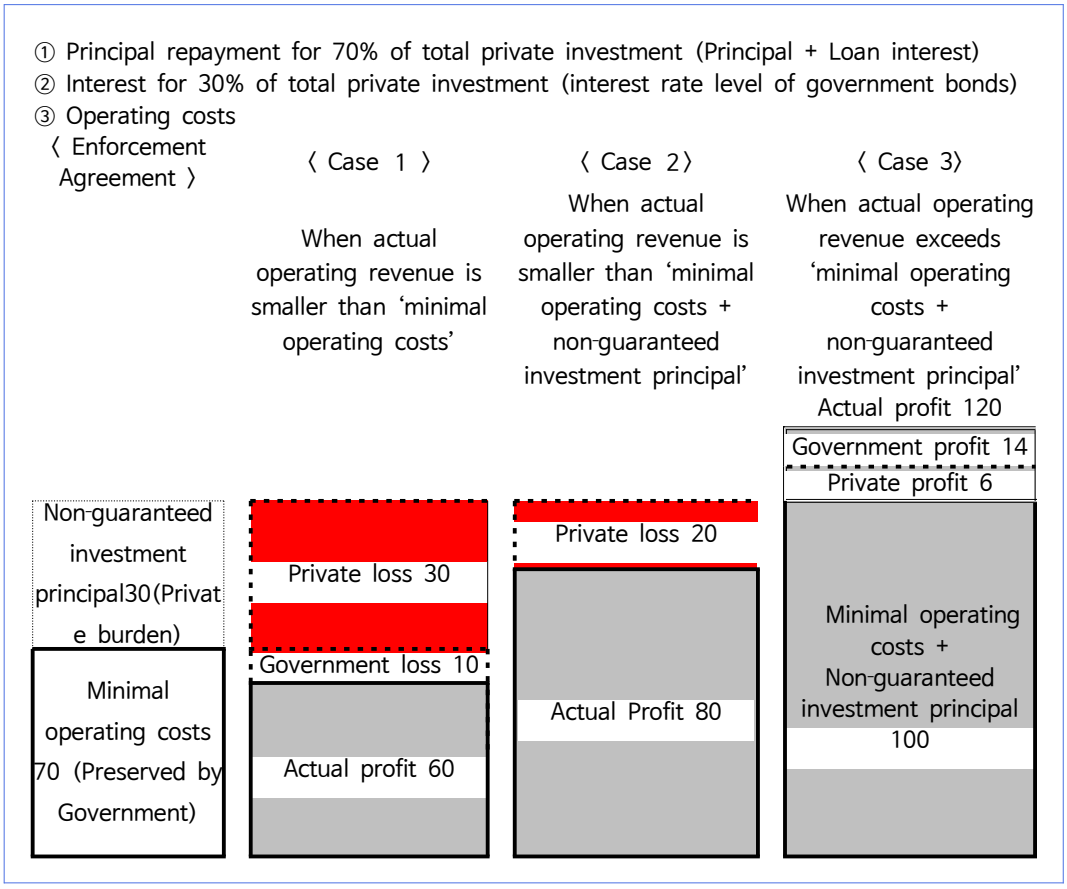
Figure 30 | BTO-rs cases by Actual Operating Revenue



3.6.2. BTO-a, Build Transfer Operate-adjusted type, Profit and Loss sharing type

This approach is suitable for projects with high public awareness because the government assumes the minimum business operation cost necessary for the construction and operation of the facility, and reduces the business risk by sharing the excess profits.

Figure 31 | BTO-a cases by Actual Operating Revenue



In conclusion, the details of PPP types such as BTO, BOT, and BTL in public-private partnership projects are determined by the nature and method of operation of the social overhead capital to be established. In order to reduce the burden on the private sector, it is preferable to increase the burden ratio of the government and lower the burden ratio of the private sector.

Colombia has welcomed private sector involvement in water since the 1990s, and Act1508 which was passed in 2012 seek to enhance the previous structural challenges. While the new regulations cover the entire infrastructure sector, both Regulation 1082 and Resolution CRA-716, passed in early 2015, provided detailed guidance of water and sanitization PPP.

Act1508 classified public work project and overall private projects. Public work projects do not have limit on the investment amount of government funds, but water related independent PPP projects have limit to 20% of government's investment share.

The World Bank has registered 52 local government water concessions and management/ lease contracts which is in process in Colombia that currently supply 30% of the city's population. According to the World Bank, the key success factor in the past was not only the flexibility of contract terms but also the government's role in the construction phase of the financing project. The government has maintained a steady rate structure and has given approvals for access to severely aging infrastructure and allowing refurbishment. The 2012 PPP Act seeks to transfer more risks, responsibilities and investment obligations to the private sector by contract.

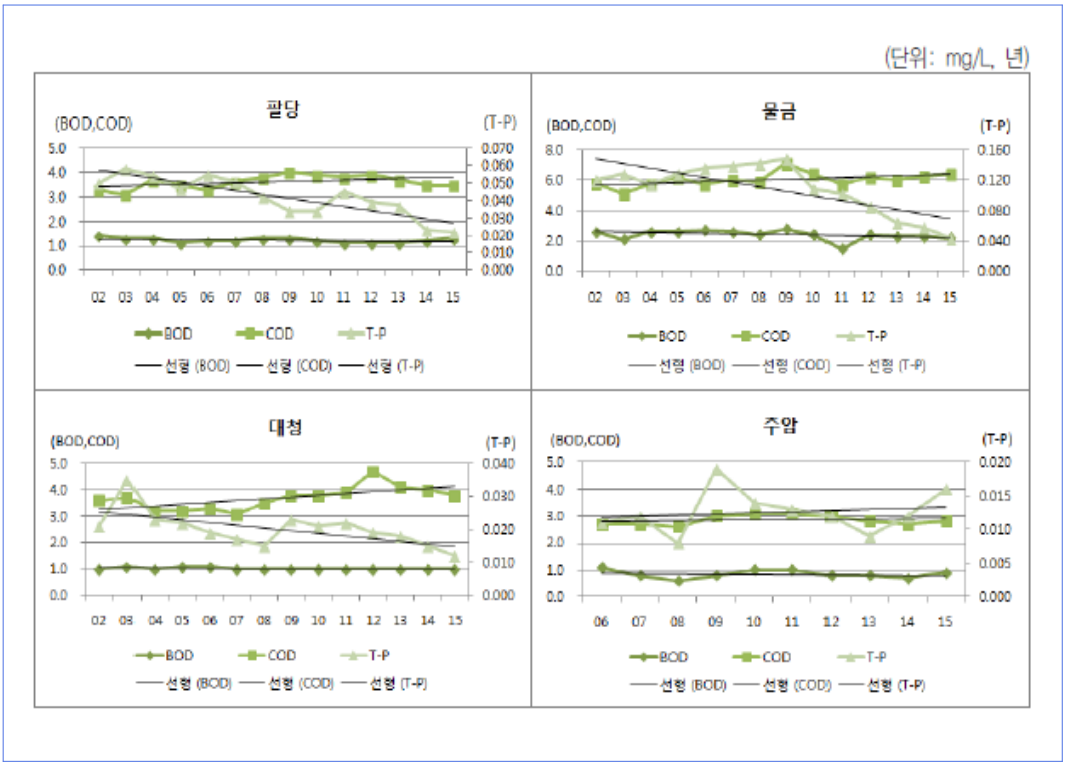
The PPP project needs to find a good balance between providing financial stability and public services, understanding that the water sector has a very low return on investment, and should have sufficient consultation between the two parties so that a reasonable contract can be concluded from the beginning.

4. Water Resources & Case Study of River Development

In order to improve the water quality in the water industry of Colombia, policies for water quality control should be put in place before accepting water treatment technologies. Korea responds with flexibility to the changes in water quality by monitoring the water quality at major points of the four main rivers. Serving as the foundation for this, there were policies such as integrative plans for water management (1998 - 2005, 2006) and the basic plans for water environment management (2006 - 2015). As a result, the BOD concentration and total phosphorus contamination in public waters are generally decreasing.

Development of the rivers and restoration of the ecosystem can be explained in relation to the development of the sewerage system. The greatest contribution to the development of the sewerage system was made when the government expanded various water management plans and financial investments, due to the Seoul Olympics in 1988 and the phenol contamination of the Nakdong River in 1991. Especially, the water system management fund raised by the enactment of the Four River Act, such as the 'Act on the Han River Water System's Potable Water Source Quality Improvement and Civil Support' and more, allowed local governments that were short of resources to engage in active investments, leading to the further development of the sewerage system (Ministry of Environment, 2016).

Figure 32 | Changes in water quality of the four major rivers



Data Source : Ministry of Environment, Environment White Paper (2016)

4.1. Cases of Han River Development

The rapid industrialization and shift of a large part of the population to Seoul after the 1970s caused increased pollution of the Han River, leading to a sudden fall in the water quality. During the continued process of urbanization during the 1970s and 80s, city sewage and factory wastewater were released, resulting in a serious situation in which the BOD was higher than 100 mg/L. The government implemented the Integrative Development Plans for Han River in the 1980s to improve public opinion and promote public health by setting up a 'Park of Water' on the Han River. This project simultaneously conducted the maintenance of low waterways, establishment of waterfronts, installment of Han River roads, and construction of classified sewers and embankments. In the 1990s, a long-term comprehensive plan for water resources was established and implemented in connection with the Third Comprehensive National Development Plan (a specific development project).

As a result of these continuous projects to improve the water quality and acts to preserve the environment, the water pollution level was reduced 97% by 2014 (BOD from 146.0 to 4.7 mg/L). Recently, the Han River Water Shed Environmental Management Office has also been planning a large-scale project to set up a waterside eco-belt for the improvement of water quality and restoration of the ecosystem. Various ecological programs connected with local festivals and industrial environments are to be developed to advertise and provide a protection plan for endangered species.

4.2. Cases of Geumho River Development

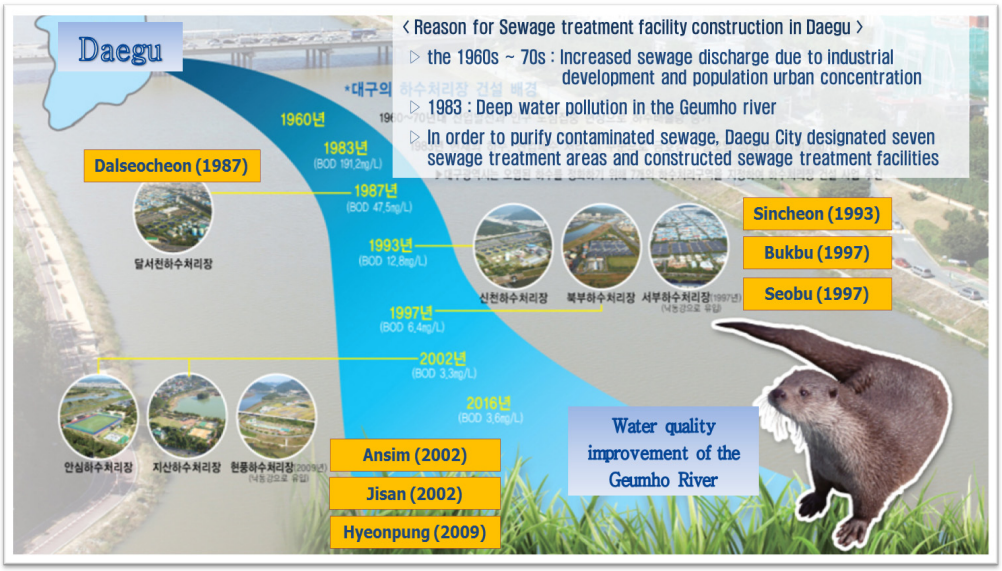
When the Ministry of Environment analyzed the water quality data of 574 rivers in the nation in 2014, the Geumho River scored the 'highest in the nation' for improvement of water quality among all the polluted rivers. The average biochemical oxygen demand (BOD) of Geumho River was 191.2 mg/L in 1983 and 3.6 mg/L in 2014, showing a water quality improvement of 98.1%.

Because the textile and dye industry flourished at the metropolitan city established in Daegu, the center of economic growth in the 1960 - 80s, various water pollutants were introduced to Geumho River. These caused numerous pollution accidents and massive fish kills. The Geumho River was referred to then as the 'River of Death'. The situation was changed when Daegu City acknowledged the severity of the river pollution and began constructing treatment plants, repairing sewers, and introducing advanced treatment facilities with the capacity to reduce total phosphorus.

In order to save the Geumho River, which had been transformed from the river it once was to a sewer penetrating the city center, Daegu city constructed the best wastewater treatment plants. They also implemented a project to construct 52 km of pipelines from Imha Dam to Yeongcheon Dam to supply the water needed to maintain the river flow, which had become insufficient from diversion of water to the Pohang steel industrial complex. As a result, the water quality of Geumho River in 2001 reached 5.0 mg/L of BOD, but Daegu did not stop there. It poured 2.672 trillion KRW into the maintenance of sewerage systems and 109.2 billion KRW into installment of five buffering storage facilities with a total capacity of 147,700 m3 to stop pollutants from the industrial complex. It invested a total of 4.1854 trillion KRW, including 12.1 billion to supply 100,000 m3/d of water to maintain Sincheon, a stream of Geumho River, 38.7 billion to create 6.1 km of ecological streams in four major river streams of the city, and 247.5 billion to construct seven sewage treatment plants (1.87 million m3/d), 5 wastewater treatment plants (95,250 m3/d) and a total phosphorus elimination facility.

As of 2015, the BOD had reached 3.0 ppm, and the Geumho River was transformed into a 'River of Life', inhabited by otters and fish. It was certainly a miraculous change. In comparison with foreign cases, it took 141 years for the salmon to return to the Thames in the United Kingdom and 23 years for the water quality of the Dama River in Japan to be restored, but only 15 years for restoration of the Geumho River water quality in Daegu.

Figure 33 | Geumho River development case

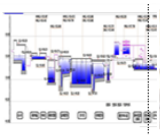
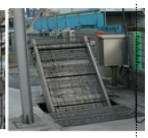


Ⅳ. Colombia Technology Demand and Korea Technology Analysis

1. Technical Analysis of Colombia and Korea

1.1. Technology Demand of Colombia

Table 41 | Colombia Technical Demand Profile

	Design and Consulting	Construction	Operation and Maintenance	Manufacturing		
Value Chain				 		
			Facility Operation and Maintenance	Chemical Material	Machine Device	IT Convergence
Priority			◎	○	◎	△
Literature search			◎	◎	◎	△
MVCT			◎	△	△	△
ACODAL			△	◎	◎	△
Tecca (company)			△	◎	◎	△
Interview with Policy Administrator			◎	○	◎	△

1.1.1. Priorities for Technology Transfer

The KSP team classified the water treatment technologies into design and consulting, construction, operation and maintenance, and manufacturing based on the value chain to figure out the demand for technology in Colombia. Considering the scope of this project, the demand was analyzed with focus on operation (management) and maintenance, and manufacturing. According to references, the sewage and wastewater treatment technologies of Colombia required transfer of technologies in management and manufacturing in general. However, when demands were analyzed by specific departments, the public sector (government) demand was for management-related technologies, whereas the private sector (corporations) demand was for technologies with more emphasis on actual products. These results were confirmed through an interview with a Colombian company (Tecca).

Thus, the KSP team designed this project so that, although the public and private sectors cannot always be clearly divided due to the nature of water industry, the public sector can be offered management know-how whereas the private sector can be offered technologies more focused on products.

1.1.2. Reference Search

A general investigation regarding Colombia's water treatment technologies was conducted based on the materials about water treatment in Colombia provided by the MVCT, DNP, and ACODAL. The investigation included materials provided by an official from the city of Bogota Bureau of Waterworks and Sewerage, who was invited to the 'Water Industry Overseas Expansion Conference' held by the Ministry of Foreign Affairs of Korea. According to the results, it was confirmed which process methods and technologies would fit the local conditions, and what training of management skills was required, for the transfer of technology to the private sector of Colombia.

The capacities to supply tools and materials, and in particular, to manage, should be prioritized in order for Colombia to achieve technical competitiveness in the field of water treatment. The manufacturing in Colombia is highly dependent on the import of foreign tools and materials, and although there are companies that can provide water treatment management services in each region, they are not as efficient as they might be due to poor management methods and lack of research and development.

1.1.3. Demand Survey of Colombian Organizations (MVCT and ACODAL)

Despite having ample water resources, Colombia suffers from a lack of sewage treatment facilities and continuously effective management. More specifically, the private sector normally takes charge of the designs, engineering, and tools and materials; whereas the management of the facilities is taken over by the public sector. The nature of the water industry prevents clear separation of public and private sectors in each field, but according to the results of the local inspection, MVCT needs training and transfer of management technologies, as part of the public sector; whereas ACODAL, as private sector, needs technology transfer in the field of manufacturing.

Because MVCT approves the designs and construction of water treatment facilities and supervises the construction process, officials there were very interested in policy administration training and facility management know-how appropriate for the wastewater and sewage treatment capacity of Colombia. However, due to limited resources, they preferred processes with lower cost, but efficient enough to improve conditions in Colombia, over the advanced, high-cost processes applied in Korea. For instance, the Cajica sewage treatment plant in Columbia comprises two biological treatment chambers and two settlement chambers, and uses a lagoon process (typical in Colombia). However, the management of the plant is very difficult, water quality analysis is conducted only once a month, and the influent water exhibits huge differences in quality and odor. Reflecting such demands, the workshop held in Korea for policy administrators included a program during which participants could visit sewage treatment facilities and learn about the management processes there.

ACODAL is a private organization that has been established for 60 years, but is an official advisor to the Colombian government and owns 1200 member companies. As the Colombian government has become more interested in sewage treatment, demand has recently increased for technology transfer from private manufacturers in the fields of sewage treatment, reuse of solid wastes, renewable energy, etc. It is legally prohibited in Korea to reuse sludge as compost or fertilizer, but not in Colombia. The legal regulations in Columbia regarding wastewater and sewage are not satisfactory, but the government has recently shown the will to enact the necessary legislation, indicating that demand in the field of wastewater and sewage will continue to increase.

The problems of the sewage treatment plants suggested by ACODAL include inadequate facilities, lack of expertise of managers, and excessive management costs. Because 80% of the population is within lower-income groups in regions other than metropolitan cities, the management costs cannot be covered by the sewage fees, causing even more problems. Also,

due to the lack of approval systems in Colombia, parts are used after a simple screening of whether they are appropriate for construction of the sewage treatment plants.

Putting the opinions of MVCT and ACODAL together, we were able to conclude that Colombia exhibits keen interest in management and manufacturing technologies. It appears premature for water service actors in Colombia to consider the fields of IT and convergence.

1.1.4. Company Visitation

Tecca is a private manufacturer of treatment plants for industrial wastewater and living sewage with sales of 20 billion KRW. When designing a plant, they use domestic products for simple materials like pumps and steel (around 50%), but most of the major components are imported.

They have experience with transfer of membrane plant manufacturing technology from Denmark, and the condition was to use Danish products when manufacturing plants of that kind. This company has recently carried out a project to install a sewage treatment plant (total capacity of 7000 t/d, MBBR process) in Lima (Peru). Tecca was most interested in tools and materials, as well as management technologies in general, that are related to sewage-wastewater treatment facilities, such as solutions using ceramic membranes for industrial wastewater treatment, high-efficiency MBBR technology, sludge dehydrators, RO, and coagulants.

1.1.5. Interview with a Policy Administrator

Even when sewage-wastewater treatment facilities are constructed in Colombia, there are difficulties in running them continuously due to cost problems. They were most interested in low-cost, high-efficiency tools and materials that could contribute to continuous management when actually running the facilities. Many expressed the opinion that they wanted to receive the know-how for advanced management of the sewage-wastewater treatment facilities in Korea.

1.2. Survey of Korean Technology

1.2.1. Primary Evaluation of Domestic Technologies

Table 42 | Summary of Korea Water Technology

Value Chain	Management and Maintenance		Manufacturing					
			Chemicals-Materials		Mechanical devices		IT Convergence	
Technology	Waterworks	Sewerage	Technology	Filter membrane	Agitator	Ventilator	Measuring instrument	Tank
	Wastewater Treatment Plants	Water Reusing Facilities	Technology	Active carbon	Pumps	Scrapers	Management solution	Flow controller
	Flocculation Filtration Facilities	Management of Underground Utilities	Technology	Water treating agents	Valves	Dehydrator	IT, NT, BT(Convergence)	Flowmeter
	Other Environmental Pollution Prevention Facilities	Dye Wastewater Treating Facilities	Technology	Membrane	Centrifuge	Ozonizer		
	Pipe Network Maintenance		Technology		Centrifuge	Dehydrator		
					Screen	Agglomerator		
					Non-point Segregator	Sludge collector		
						Shipboard sewage treating facilities		

A survey was conducted to provide a reference when matching Colombian companies with Korean companies who are more likely to transfer technology. This was done by understanding the current status of companies available for technology transfer, rather than companies that are simply related to water services, so that Colombia's wastewater and sewage treatment technologies can improve.

The subjects of this survey were selected from the list of companies (2535) in the 2012 Water Industry Statistics Report (June, 2013, Korea Water and Wastewater Works Association) based on the size of business, capacity for R&D, and type of core business. Those that have sales at 5 billion KRW and above (or have more than 50 employees), that have a research institute and R&D performance, and that are mainly focused on specific products (i.e., filtration systems, membranes, flow meters, pumps, pipes, ion exchange, sterilization/oxidation system, screening facilities, standard treatment devices and systems, and valves). The resulting list of Korean water treatment technologies that could be applied in Colombia by each value-chain in the water industry is shown in Table 42. Based on the technologies suggested in Table 43, a demand survey was conducted in Colombia, which was followed by the primary technical assessment of domestic technologies.

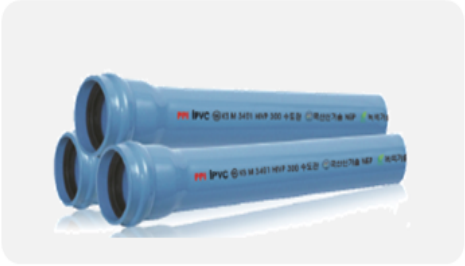
The first technology evaluation was conducted by the experts of Dyetec Research Institute, Yeungnam University, Daegu University, Keimyung University, etc. (20 years of experience in water treatment technology development, support for domestic company overseas advancement and overseas water treatment technology consulting experience) which they have reviewed and derived to a technology that is suitable for Colombia.

Table 43 | Representative Technologies Identified in Primary Evaluation

No	Value Chain	Technology
1	Management & Maintenance	Other environmental pollution prevention facilities, flocculation filtration facilities, pipe network maintenance, water reuse facilities, management of underground utilities, dye wastewater treatment facilities
2	Manufacturing	(Chemicals and Materials) Pipes, carriers, water treating agents, membranes, anhydrous urinal
		(Machines or Devices) Agitator, pump, valve, dehydrator, centrifuge, dehydrator, screen, agglomerator, water tank, sludge collector, non-point segregator, shipboard wastewater treating facilities
		(IT and Convergence) Flowmeter, flow controller

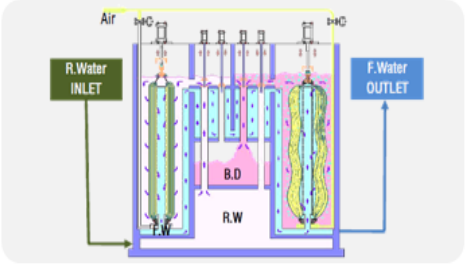
Figure 34 | Representative Technologies of the Primary Evaluation Result

APPIZ Water Pipe

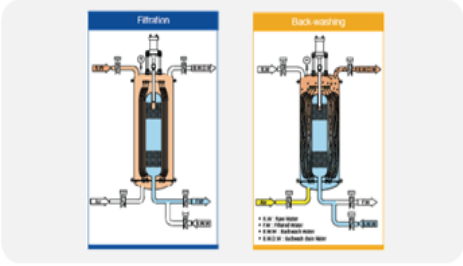


iPVC DH2040 Pipe(DWV)

GFF(Gravity Flow Fiber) Filter



PCF(Pore Controllable Fiber) Filter



Drinking Water and waste water treatment facilities

Trash rake screen

Industrial wastewater Advanced treatment facilities

Bio filter for treatment of odor-gas

Water treatment facilities

Sludge collector

1.3. Matching Korean Technology to Colombian Demand

1.3.1 Introduction of Technology and Secondary Evaluation of Domestic Technologies

From 16 - 20 January 2017 (5 days), a workshop for policy administrators was held with four Colombian officials from water treatment-relevant departments to share Korea's water treatment policies and experiences regarding establishing and managing infrastructure. On 20 January (Friday), candidate technologies for transfer were introduced and technical consultation took place. This event allowed companies to directly present technologies needed by Colombia that were selected from the primary evaluation of domestic technologies. The secondary evaluation took place through Q&A and interviews with the Colombian officials.

The Colombian officials were interested in the technology used to manufacture biological membrane carriers for wasted protein from leather byproducts for the highly efficient treatment of industrial wastewater. The hydrophilic carrier containing waste gelatin provides the same effect with lesser amount, does not require pre-chemical treatment for highly concentrated organic substances, and is effective in reducing the management costs by cutting down costs for chemical agents. The 3-way screening received much attention for its capability to remove most of the impurities in various plants and to resolve problems with high concentration/high burden. Korean agitators were also positively regarded by the Colombian officials because they could save more than 60% of the energy now used, reduce costs for chemical agents, and perform with high efficiency, which is proven by deviation of the MLSS concentration within 10%.

However, Colombia currently uses the natural drying method over a wide area to treat sludge, and sludge-related legal regulations are non-existent. Thus, there were opinions stating that Colombian demand for high-efficiency sludge collectors, dehydrators, and deodorizers are not adequate at the moment to support transfers. Furthermore, the Colombians were more interested in the technology transfer in regards to sewage treatment rather than for water supply, and the level of attention for screens (rotary dust collectors) in the Colombian market was low (as expected), because they are mostly used in waterworks.

Thus, we have conveyed our opinions to MVCT of Colombia that the hydrophilic carriers with wasted gelatin, 3-way screens, and agitators are the most appropriate technologies to be transferred considering Colombia's current situation.

Table 44 | Representative Technologies of Secondary Evaluation Result

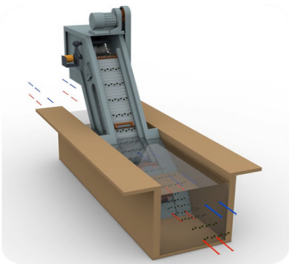
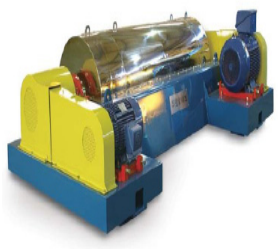
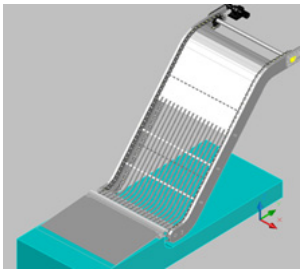
Products	Details	Selected Company
Hydrophilic carriers with waste gelatin 	• (Classification) Carriers • (Technology) Technology used to manufacture biological membrane carriers for waste protein from leather byproducts for the highly efficient treatment of industrial wastewater • (Type) AC-PVA carriers, foaming agent PVA carriers • (Expected outcome) Required area reduced, can skip pre-chemical treatment for highly concentrated organic substances, costs for chemical agents reduced, energy costs saved by not returning sludge	GE Tec. Co., Ltd.
3-way screen 	• (Classification) Screen • (Technology) 3-way screen • (Expected outcome) Various plant impurities removed, high concentration/high burden problem resolved	ESSA
Agitators 	• (Classification) Agitators • (Technology) water-treatment exclusive impeller, GOPT Control • (Type) Top entry agitator, Side entry agitator • (Expected outcome): Improved scum removal and denitrifying efficiency, reduced management costs from energy saving, etc.	Woojin
Centrifugal dehydrators 	• (Classification) Dehydrator • (Applied field) Manufacturing processes including sludge from waterworks, sewage, excreta, livestock wastewater, concentration and dehydration process, pre-treatment, etc. • (Expected outcome) Treat as dried sludge by dehydrating as a whole in short period of time	-

Table 45 | Representative Technologies of Secondary Evaluation Result (Continue)

Products	Details	Selected Company
Rotary dust collector 	• (Classification) Screen • (Technology) Horizontal screen, sedimentation-preventive dust collector • (Type) Rotary dust collector • Expected outcome) Minimize head loss and replacement allowed for each parts	-
Multi-deodorizer 	• (Classification) Deodorizer • (Technology) Remove contaminants from highly concentrated gas • (Type) Multi-deodorizer with photo-catalysts and biofilters for the removal of stinking gas • Expected outcome) Discharge externally as odorless gas	-
Driving sludge collector 	• (Classification) Sludge collector • (Technology) Auxillary scraper collects the sludge, controlling system of sludge collecting instrument, tension controlling device for sludge collector	-
Circular sludge collector 	• (Classification) Sludge collector • (Technology) Induce swirling flow of sewage particles to increase reaction time	

1.3.2. Final Selection of Domestic Companies (Participants of Dissemination Seminar in Colombia)

A survey was conducted to figure out the technologies available for transfer from Korea to Colombia. Included in the survey were 325 companies, of which 87 responded. Thirteen companies related to the eight technologies prioritized for transfer to Colombia, were selected by primary evaluation.

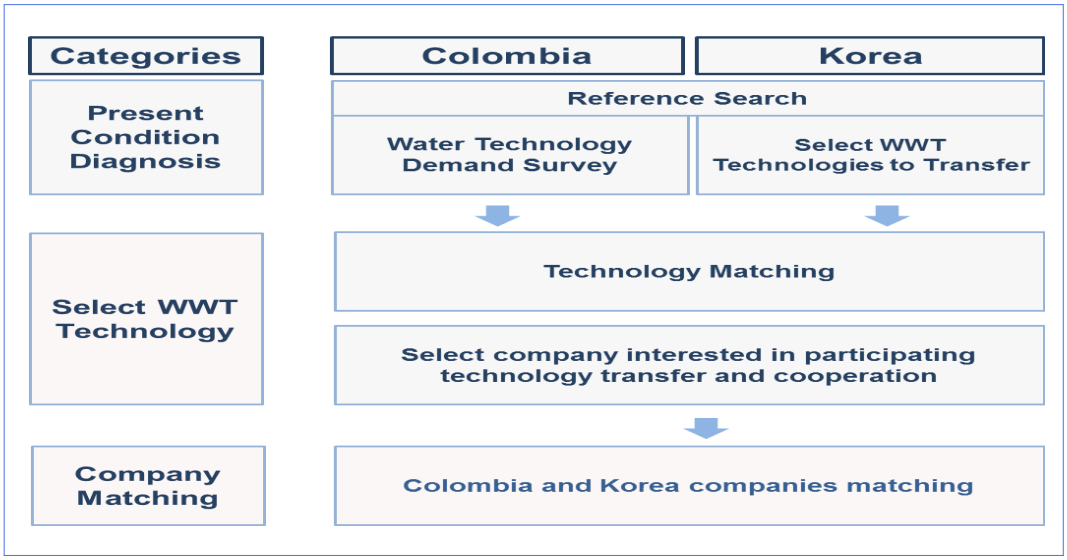
Secondary evaluation was conducted as the primarily selected companies introduced their technologies to the Colombian policy administrators. They reviewed the Korean technologies very thoroughly, focusing on the local legal regulations, market demand, and applicability of the technology. Three technologies (hydrophilic carriers with wasted gelatin, 3-way screen, agitators) were selected as appropriate for matching with a recipient company, considering the current situation in Colombia.

In selecting the domestic companies, the primary evaluation focused on whether they are capable of technology transfer and how interested they are in the Central/South American market. Three companies (Woojin, ESSA, and GE Tec. Co., Ltd.) were chosen after finalization through the presentation evaluation with the Colombian policy administrators. The selected companies will proceed with discussions with Colombian companies at the final dissemination seminar, in various directions that include such as technical consulting and technology transfer.

1.4. Conclusion

This KSP project ⟨Figure 35⟩ prepared for the matching of companies through three steps used as the selection process of domestic technologies and companies. During Step 1, general information regarding the water treatment field was collected by studying Columbian references. We also shared the current situations and difficulties in Colombia in the meeting with our counterparts MVCT, ACODAL, and a Colombian company (Tecca) during our field visit for the initiation report session (local presentation). Meetings with domestic organizations (KEITI) / companies (Hyundai E&C, Daewoo E&C) that have expanded to Colombia were of great help in understanding the local situations. In the meanwhile, an investigation was conducted in Korea to figure out the technology appropriate for the situations in Colombia.

Figure 35 | Korea Technology and Enterprise Selection Process



In regards to the selection of companies to transfer technology in Step 2, the opinions of the four Colombian policy administrators who participated in the meeting were collected about the technologies investigated in Step 1. An interview session and an actual technology presentation were conducted regarding the fields currently available for technology transfer to Colombia. Based on the selected technologies, the companies to participate were finalized, and the relevant information was shared with MVCT, our counterpart. Company matching will be conducted after receiving recommendations of Colombian companies who can actually receive the technology in the designated field, and Korean companies who are interested in the selected technology (those who are considering expanding the range of their business).

V. Policy Proposals for the Establishment of Technology Transfer Plans

1. Proposals regarding Technology Transfer Plans

1.1. Cooperation between companies

The fundamental aspect of the technology transfer between Korea and Colombia is that it should be based on cooperation between corporations. Close communication is necessary to achieve a win-win situation, particularly in cooperation with a foreign company, because there are diverse variables such as geographical limits, differences in business management style or attitudes of members (cultural differences), economic conditions, etc. This KSP project is about the KSP team (Daegu Technopark, KECC, DYETEC Institute) serving as a bridge between Korean and Columbian companies that currently have no channel through which to communicate.

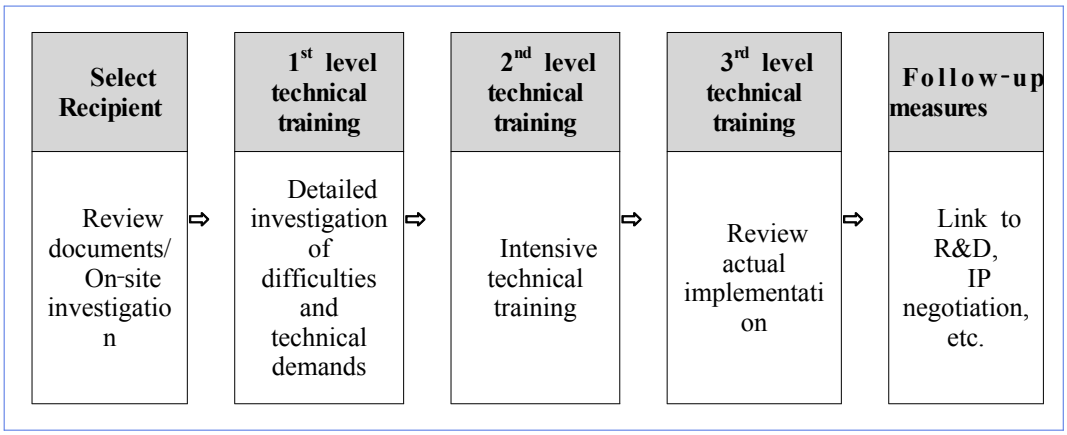
However, this technology transfer KSP project is not enough to improve the water treatment technologies of Columbia. Thus there is a great need for follow-up projects such as, but not limited to, ① technical assistance and transfer of know-how to Colombian companies to resolve technical difficulties, ② support product development, testing evaluation, production of trial products, etc., ③ support networking between companies in Colombia and Korea and finding new markets, and ④ support for additional technology transfer (licensing, establishing joint ventures, etc.).

Focusing on the Korean technologies (products) that can be applied to Colombia according to this KSP project, further projects can be conducted in the order of the technical training process of Figure 36, starting from the selection of additional Colombian recipient companies and 3-level technical training (investigate difficulties → intensive technical training → review operation); leading to R&D or joint ventures. Regarding details of the technical training process, it can be divided into a first level in which the information regarding the difficulties Colombian companies are facing are collected via direct visit; a second level in which technical training

takes place for on-site resolution of the difficulties; and a third level in which the application and cooperative measures are discussed.

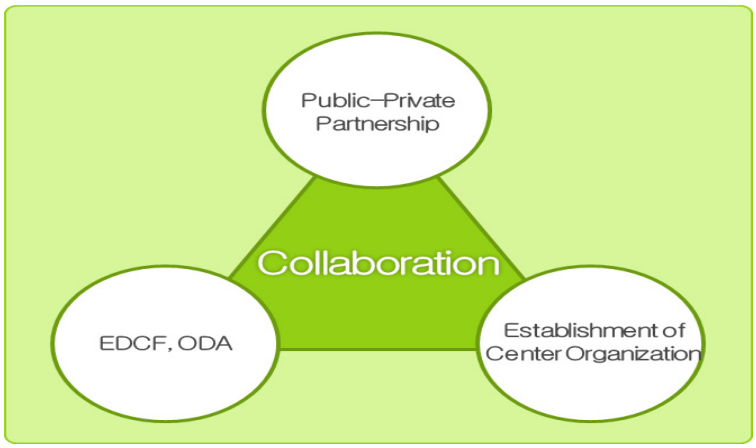
Through the technical training process, a cooperative partnership between the two companies is encouraged to continue cooperation even after the project has concluded. Also, follow-up projects (PPP, ODA, etc.) are discussed to support private investment.

Figure 36 | KSP Follow-up Project Technical Training Process



Furthermore, apart from the aforementioned detailed follow-up projects, the KSP team proposes the Public-Private Joint Investment Project through the connection between the private and public sector, EDCF or ODA projects, and the technology transfer through the establishment of a technical cooperation center as the measures to improve the water treatment technologies of Colombia. Each proposal has already been adopted in Korea to improve technologies of other countries, and the specifics are to be discussed in separate chapters.

Figure 37 | Technology Transfer Model



1.2. Representative Cases of Technology Transfer

1.2.1. Technology Transfer Model with Public-Private Partnership

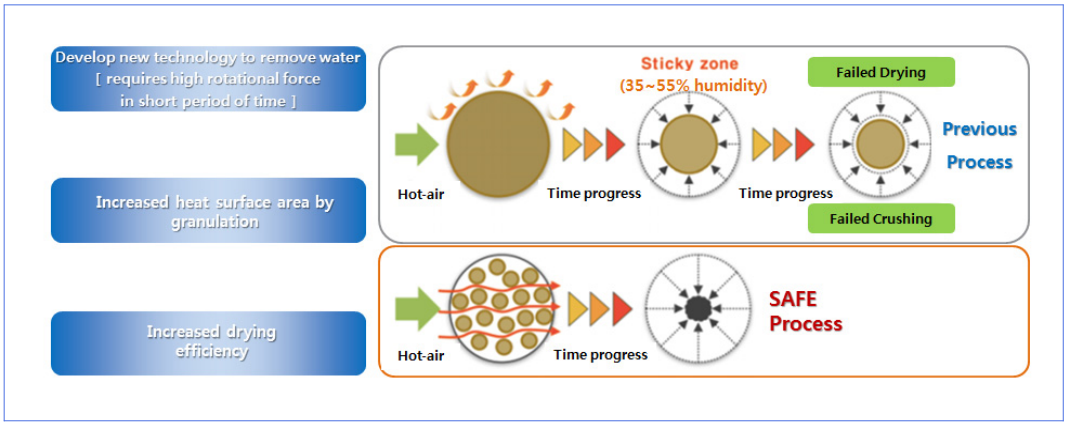
1) EnbioCons Co., Ltd. transfers water treatment technology to China (2015.12)

This was implemented in a format where environmental organizations of Korea and China discovered companies with the technologies to provide joint investment. A technology transfer contract worth 100 million CNY and a quadripartite contract for Korea-China management joint investment worth 400 million CNY were concluded. Local governments in Korea and governmental organizations in China participated in the partnership with private corporations. For the first time in Korea, a contract was concluded in which Korean companies received fees from Chinese companies for technology transfer.

EnbioCons Co., Ltd. of Korea became the first domestic environmental company to receive 100 million CNY (18 billion KRW) for the transfer of technology from Jiangsu Philips, Ltd. of China. A joint venture specializing in sewage treatment in China was established by EnbioCons Co., Ltd., Jiangsu Philips Ltd., Daegu Environmental Corporation, and Yixing Industrial Park for Environmental Science & Technology with 400 million CNY (72 billion KRW) of joint investment.

Enbio Cons Co., Ltd. is the leading firm in the field of dryers used to dry waste sludge for utilization as a resource. Jiangsu Philips, Ltd. of China manufactures and manages water treatment facilities such as aeration chambers and air diffusers.

Figure 38 | Sewage Sludge Utilization Process of EnbioCons Co., Ltd.

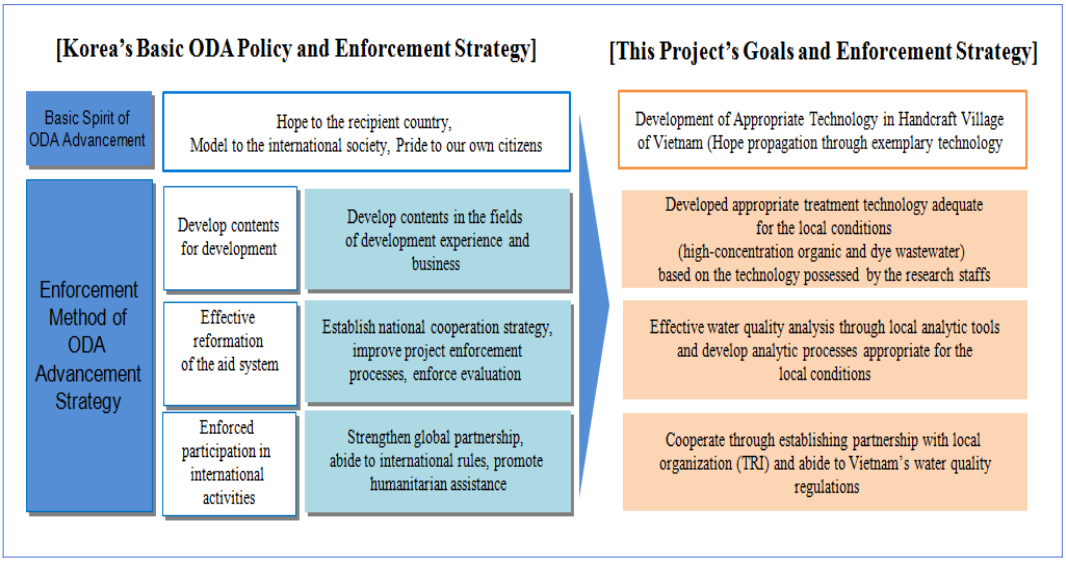


The joint venture will expand its shares in the Chinese sewage treatment market through projects on the treatment of sewage sludge in general, including the design, construction, and management of sewage sludge plants. Because the water market of China is expected to become worth 100 trillion KRW in several years, the joint venture will receive orders regarding sewage treatment plants from all over the country and is expected to grow to become worth 10 billion CNY (1.8 trillion KRW) by listing in the Chinese stock market. When the joint venture begins to receive orders for environmental facilities in China, the core facilities and equipment will be supplied by Korean companies.

2) DYETEC Institute develops and distributes wastewater treatment technology in Vietnam (2016)

Appropriate technology for environmental management in a handcraft village of Vietnam was developed for commercialization by establishing the technology appropriate for removal of color from food and dye wastewater, a demonstration project, related education, and DB; as well as a global network.

Figure 39 | Wastewater Treatment Technology Development and Supply in Vietnam

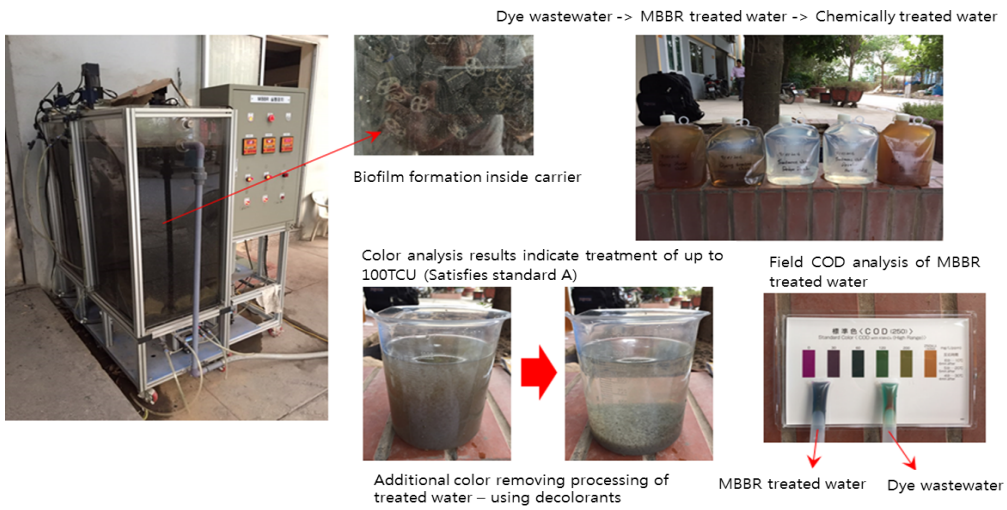


The objectives of this project are as follows: Establishment of a local institutional base for the development of appropriate technology for customized wastewater treatment in a handcraft village. This would utilize the infrastructure of participating agencies in Vietnam, construction of environmental analysis equipment through utilization of VTRI (Vietnam Textile Research Institute) infrastructure of participating institutions and funding of VTRI, and establishment of dye wastewater and high concentration organic wastewater-specialized technical support and data.

Projects for training manpower about the technology would include dispatching specialists and developing training programs for wastewater treatment plant operation, management, and analytical technology. This includes the participation of local workers in domestic education programs, joint development of high-concentration organic food-and-dye wastewater color-removal technology, and the establishment of a domestic, local one-stop technical advisory system through the local office of a representative.

A pilot scale project for wastewater treatment at handcraft villages, was established through support for commercialization by transfer of relevant appropriate technology and information to local companies. Institutional independence and a commercialization strategy were established through participation of domestic companies and a strategic technology network to achieve the complete technology.

Figure 40 | Development of appropriate technology for wastewater treatment in Vietnam



The results from the project included the development of and assistance with dye and organic wastewater treatment technology reflecting the local situation of various handcraft villages. A mid- to long-term customized technical support plan was developed for wastewater treatment and environmental analysis technology, which could support the independence of local companies and institutions (by establishment of self-funding analysis equipment by local institutions). Access was provided for entry of domestic companies and institutions into the markets of developing countries and improvement of local quality of life was achieved through job creation and improved environment.

3) Green EnTech transfer of water treatment plant technology to developing nations (2013)

Following a proposal from the Ministry of Environment, the technology research center of Green EnTech developed an appropriate technology for water treatment in developing nations and transferred this technology to six nations. The sewage treatment plant technologies transferred to the developing nations allowed the provision of purified water, and the patents for the related technologies were transferred to 'Engineers and Scientists without Borders'.

In order for the ODA regarding environmental technologies in developing nations to be successful, the appropriate technology should in demand in the particular field of the local market. It is also important to transfer technology adequate for the local conditions, which can also generate profit so that the people can utilize that technology to break out of poverty. The appropriate technology should be simple enough for the users to manage, energy-efficient, environmentally benign, labor-intensive, and controlled by the local community.

4) Korea Technology Finance Corporation concludes discussion to transfer domestic wastewater treatment technologies to Vietnam (2015.4)

The Korea Technology Finance Corporation participated in the「Seminar on the Technology Transfer in the field of Wastewater Treatment for the Promotion of Transaction and Expansion of Green Climate Technology」and successfully concluded the discussion regarding the overseas transfer of domestic technologies. The Korea Technology Finance Corporation introduced domestic companies with outstanding technologies in the field of wastewater treatment and presented on the topic of technology finance and utilization of technology evaluation systems for the promotion of the transfer of global green technologies.

Green Tech Co., Ltd. (Representative: Ja-yeon Kim), ANT21 Co., Ltd. (Representative: Myung-han Ko), MS Tech Co., Ltd. (Representative: Myung-hoe Hwang), Jiu Corporation (Representative: Jae-won Lee), and Hanil Biotech, Co., Ltd. (Representative: Kwan-ho Jeong), which are companies with outstanding technologies in the field of wastewater treatment, signed the MOU for the technology transfer with water treatment companies of Vietnam.

They discovered eleven companies with outstanding technologies in the field of wastewater treatment who were willing to participate in the transfer of technologies to overseas through WIPO GREEN, and increased the probability of success by directly providing the 'International Technology Assessment' to the overseas organizations with demand for the technologies.

1.2.2. EDCF, ODA Project Model

1) EDCF, ODA Project Cases

In 2017, ODA projects are currently worth 2.7286 trillion KRW. There are 42 organizations (including nine local governments) conducting 1295 projects. Bilateral projects account for 83% whereas multilateral projects are about 17%. The proportion of loans to grants is about 41:59.

Figure 41 | ODA project size in 2017

Categories	Asia	Africa	Central South America	Middle East/CIS	Oceania	Others
Size (1 hundred million won)	8,448	3,951	1,355	1,834	119	6,850
Proportion(%)	37.5	17.5	6.0	8.1	0.5	30.4

73% of 24 countries of central cooperation (loans 84%, grants 58%) supported (excluding multi-regions and undecided)

In case of Korea, most support is focused on commercialization, poverty eradication, education, water and sanitation, and health, in which it has comparative advantage. Sixty-one projects are related to water and sanitation with a budget of 239.7 billion KRW. Water treatment support projects in the form of loans include the sewage treatment project in Juigalpa, Nicaragua.

The aids from EDCF were mostly focused on establishing infrastructure, whereas the supports in the form of ODA were carried out as workshops or education.

Table 45 | Major Performances of KOICA Relevant to Water Resources

Project Name	Period	Sum(10 thousand USD)
Execution designing of construction of hydroelectric power plant in Modi river, Nepal	1993-1994	73
Execution designing of construction of hydroelectric power plant in Chameliya, Nepal	2000-2002	66.3
Feasibility study of construction of small hydroelectric power plant in Tad Salen, Laos	1996-1997	18.3
Assistance in establishment of embankments on the Mekong River, Laos	1997	36
Construction and feasibility study for repairing embankments at Mekong riverside and establishing a park in Vien Tien, Laos	2006-2007	80
Execution design and feasibility study of construction of multi-purpose dam in Kariyan, Indonesia	2004-2006	152
Investigation of valley in Bunha River in Shanxi Province, China, and feasibility study of construction of the Baiyekau Dam	1994-1996	78.8
Assistance in restoration of Ta Mok Reservoir in Cambodia	2002-2004	137
Feasibility study of water resource development in Krang Ponley riverside in Cambodia	2004-2005	74
Establishment of comprehensive plan for water resource development in Cambodia	2006-2008	149
Construction of small hydroelectric power plant in Muana, Fiji	1997-1999	20
Development of drinking water in Ethiopia	1995-1996	80
Development of wells in Borena, Ethiopia	2006	25
Development of drinking water in Kilte- Awlaelo, Tigray, Ethiopia	2007-2008	175
Development and repairing of wells in Kenya	2006-2007	37
Establishment of water purification plant in Asembo and repairing of Suswa waterworks in Kenya	2007-2009	242
Development of drinking water in Tanzania	2006-2008	150
Development of drinking water and feasibility study on installing waterworks in Peru	2004-2006	70
Modernization of waterworks and sewerage in Iraq	2005-2007	600
Feasibility study and establishment of flowing hydroelectric power plant in Tajikistan	2009-2011	280
Feasibility study and establishment of master plan for water supply facilities between Kariyan dam and Serpong, Indonesia	2010-2011	150
Construction of small detention facilities to reduce harms from floods and to secure agricultural water in Philippines	2010-2012	630
Restoration of water resources in Khariji, Azerbaijan	2010-2012	120
Feasibility study of construction of Guaserique II Dam in Honduras	2011-2012	98
Water supply and wastewater treatment in Punjab, Pakistan	2011-2013	400
Establishment of water resources management center in Pakistan	2011-2013	300
Research on river basin management to prevent pollution in the Yellow Sea in China	2010-2015	80

Table 46 | EDCF Major Achievements Related to Water Resources

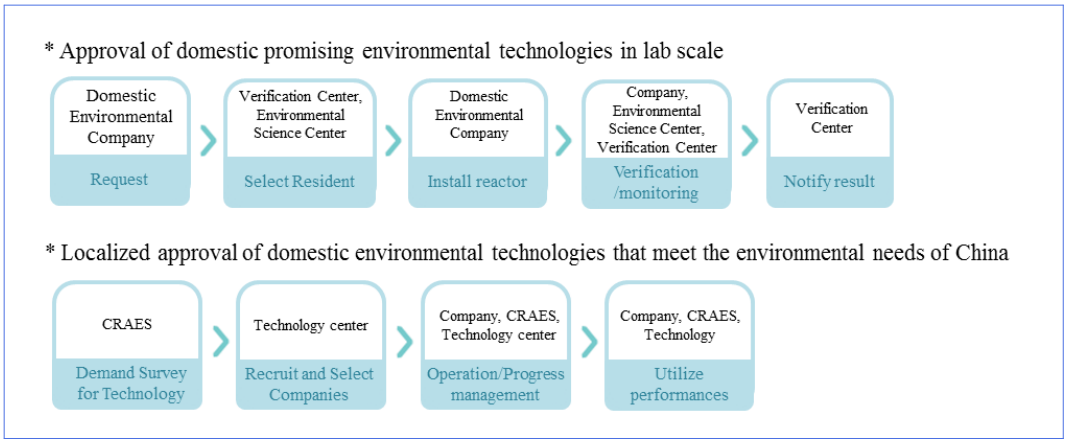
Approval date	Completion inspection day	Country	Project Name	Type of Loan
1991-03-09	2004-06-28	Jordan	Wastewater treatment facility 1st project	Development business loan
1992-08-06	2001-01-04	Turkey	Gaziantep City Modernization project of Water Supply Pipes	Equipment Loan
1995-05-26	2004-12-10	Vietnam	Thien-Tan Waterworks Project	Development business loan
0995-10-20	2001-03-22	China	Yanji City, Jilin Province Waterworks Project	Equipment Loan
1996-12-27	2004-06-28	Jordan	Madaba City Wastewater treatment facilities expansion project	Development business loan
1997-08-18	2003-12-03	China	Moowee City, Gansu Province Waterworks Construction Project	Equipment Loan
1999-12-08	2008-04-28	Indonesia	Hospital wastewater treatment facilities expansion project	Development business loan
2000-07-04	2004-12-10	Vietnam	Thien-Tan Waterworks Project	Development business loan
2000-10-25	2010-04-26	Sri Lanka	Gall Metropolitan City Waterworks Development Project	Development business loan
2004-08-31	2011-07-01	Sri Lanka	Gall Metropolitan City Waterworks Development Project (2nd)	Development business loan
2004-10-12	2010-07-26	Nicaragua	Juigalpa Waterworks Expansion Project	Development business loan
2006-11-03	2011-07-01	Sri Lanka	Gall Metropolitan City Waterworks Development Project (2nd) (Supplementary loan)	Development business loan
2007-12-31	2011-05-11	Nicaragua	Hui Golpa Waterworks Expansion Project (2nd)	Development business loan
2008-12-24	2015-08-26	Cambodia	Siem Reap Sewage treatment and river maintenance project	Development business loan
2008-12-24	2015-11-12	Sri Lanka	Ruhunupura Waterworks Development Project	Development business loan

1.2.3. Technology Transfer through Establishment of a Central Organization for Technical Cooperation

1) KEITI establishes Korea-China Environmental Technology Verification Center in China

KEITI and the Chinese Research Academy of Environmental Sciences (CRAES) co-founded the 'Korea-China Environmental Technology Verification Center' in Beijing, China in 2014. The Korea-China Environmental Technology Verification Center will cooperate with CRAES, the best environment-specializing organization in China, to dual-approve advanced technologies of domestic environmental companies in Korea and China, and support commercialization in China.

Figure 42 | Korea-China Environmental Technology Verification Center: Approval Process



In order to enhance competitiveness after market entry, domestic companies seeking to enter the Chinese market can receive support for Korea-China dual verification and field verification of domestic environmental technology by receiving a credible technical verification report issued by the CRAES. In addition, since its establishment in 2014, it has issued a total of 60 CMAs to domestic companies, and will also provide test analysis and advisory services for the acquisition of Chinese approval of domestic environmental products in the future.

Figure 43 | Korea-China Environmental Technology Verification Center: Provided Support

[Test Analysis] Korea-China test analysis and Chinese national CMA issuance for local environmental samples of Korean companies
[Environmental Technology Verification] Conduct verification of performance and reliability through lab tests (2 sites) together with CRAES to allow domestic environmental technologies to be commercialized in China
[Korea-China Co-research about Localization] Participation of small and medium sized domestic environmental companies with promising technologies to enter China, Establish verification and entry foundation for localization through co-pilot scale
* Link with international project to assist local commercialization, Verify localization whether it meets China's environmental needs

KEC System Co., Ltd., a Korean small-to-medium sized environmental company, along with the Korea-China Environmental Technology Verification Center, is carrying out a project 'developing integrated process for livestock manure disposal and recycling suitable for China', and is promoting the commercialization of livestock manure bio-gasification in Liaoning Province, China. In addition, the Korea-China Environmental Technology Verification Center formed a joint research group with Korea and China to cooperate with the Air Quality Research Institute of CRAES to analyze the air quality in China. The joint research group also carried out waste resource development sewage-sludge reduction projects in response to China's technological demand.

1.3. Proposal of Technology Transfer Model

The public-private partnership type technology transfer model is an innovative way to assist development, which aims to achieve public goals such as efficient management and private expertise while co-raising the funds. In general, public-private partnership in economic development means providing public services through private investment in infrastructure or large-scale development projects. In order to eliminate public resources and inefficiency and to promote large-scale projects efficiently, the responsibility is shared and implemented in the long term, in most cases. Public-private cooperation in international development cooperation means that both private capital and ODA (bilateral or multilateral aid) are put into action simultaneously in the promotion of projects aimed at improvement in developing countries.

When public grants and private capital is put into action simultaneously, it indicates a partnership that aims to achieve public, social, and certain private goals (business goals), as illustrated below.

In this context, the aid agencies of developed countries recognize the private sector as an important partner for enhancing the effectiveness of development. Developed countries operate a variety of public-private partnership programs, thereby creating successful cases of international development cooperation using appropriate technology.

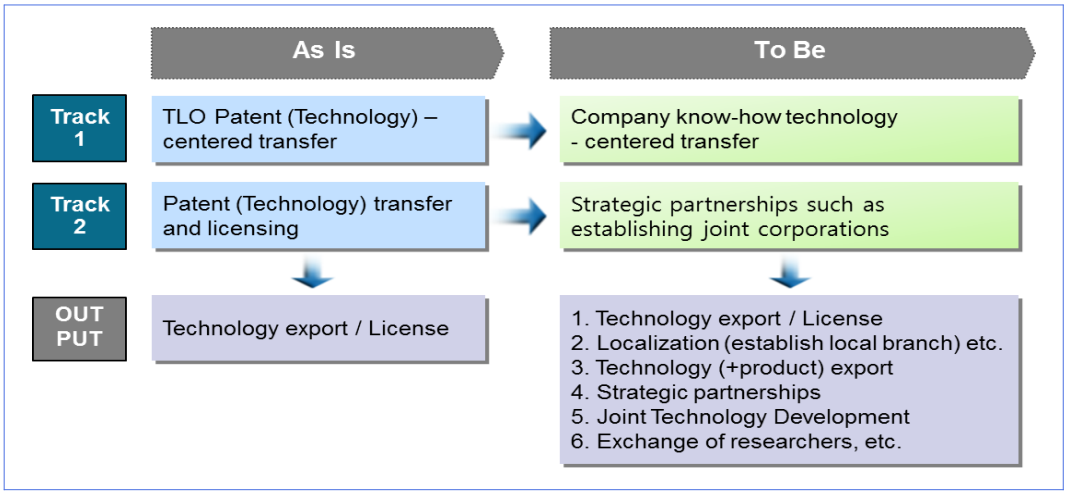
As part of the "International Development Cooperation Advancement Plan" in 2010, Korea is expanding its cooperation with the private sector by setting a policy goal of "development cooperation with the citizens", in order to expand the foundation of international development cooperation. Since then, KOICA has been recruiting joint projects between private and public sectors, and carrying out business under the brand name Global CSR (from 2011). Although domestic aid agencies are trying to improve the effectiveness of international development cooperation through the revitalization of public-private partnerships, this is still in its infancy. This movement, which is mainly led by academia and NGOs, is looking to network with international institutes while resolving their initial anxieties.

It is necessary to find a variety of water treatment technologies and global cooperation models suitable for Colombia, to support the technology cooperation programs appropriate for local countries, rather than simple transfer of patents and technologies. Long-term cooperation models such as transfer of know-how and establishment of a joint venture will be more appropriate than the simple technology transfer given Colombia's water treatment technology. A joint investment between companies would be the most effective model, and a rather comprehensive connection would be necessary, such as through private-public joint investment, EDCF or ODA projects, with establishment of a central organization for technical cooperation.

In the case of Korea's large enterprises or small-to-medium-sized enterprises (SMEs) with technologically superior technologies, transfer of these to companies of developing nations in the context of development cooperation, may provide opportunities to enter new markets, but also requires taking appropriate risks in the process.

There are various cases of transferring environmental technologies, both successful and unsuccessful, in the private sector. However, it is a process that is not an independent part of international cooperation, and it can contribute to the expansion of profit of both participants of the technology transfer in the long term. Companies providing the technology can enhance their understanding and cooperation with recipient countries and companies through technology transfer projects. Environmental technology cooperation and mutual understanding can serve as a foundation for expanding profit through future projects.

Figure 44 | Technology Transfer Model



Therefore, while the previous technology transfer model focused on the patent (technology) and licensing, the direction of the model suggested in this project should generate mutual profit by transferring the practical know-how of a company, based on the strategic alliances like establishment of joint ventures.

Ⅵ. Conclusion

The establishment of 'Technology Transfer for Water and Wastewater Treatment Industry in Colombia' aims to review the water treatment in Korea and Colombia and provide opportunities to enhance the water treating capacities of Colombia. There are two main goals in this KSP project. First, it aims to provide advice regarding management policies by establishing a PPP-based water treatment infrastructure. Next, it aims to discover technologies to be transferred in the field of water treatment to enhance the technical capacities of the local companies and to establish a technical transfer-cooperation channel.

In order to achieve the two aforementioned goals, this KSP project was implemented in the following order: ① Investigation of the conditions of water treatment in Colombia utilizing local networks, ②Analysis of water treatment policies and industries in Korea and case study of PPP, ③Confirmation of the demand for products and services from Colombia's water treatment related departments and local companies through a field visit, ④Survey of the domestic water treatment companies regarding the demand for technology transfer, ⑤ Establishment of channel for policy consultation and cooperation through the invitational workshop for Colombian policy administrators, and ⑥Discovering the technology to transfer and suggesting the transfer plans.

The field inspection regarding water treatment in Colombia shows a high distribution rate of waterworks in urban regions but an extremely low level of distribution of sewerage, even when considering the distribution of pipes rather than the sewage treatment rate. The situation is even worse in the fields of manufacturing water treatment equipment and facilities and O&M. Thus this KSP project is focused on providing policy advice regarding the installation and management of sewage treatment plants to improve the sewerage distribution rate and to establish a channel for technical transfer and cooperation regarding the fields of water treatment facilities and equipment.

Most of the water treatment infrastructure in Colombia was installed using loans from the World Bank or IDB or ODA funds. Recently, the Public-Private Partnership is most preferred.

BOT (Build-Operate-Transfer) is the most common arrangement in Colombia, which is normally introduced in developing the infrastructure in developing countries who face difficulties in raising funds. However, BOT projects require a relatively longer construction period and higher risks due to its dependency on political stability. In Korea, most water treatment infrastructure adopts the BTO (Build-Transfer-Operate) model, which is a profitable private investment project normally implemented for facilities with management profits sufficient to retrieve the investments. There are differences in the type of PPP utilized in both nations, but the analysis on Korea's PPP cases and the field visit to the Pohang Sewage Treatment Plant served to provide useful advice to the Colombian policy administrators.

Colombia's water treatment management system is very inefficient. This mainly stems from the high burden of management and maintenance costs caused by a shortage of professionals in water treatment management, and by high energy costs. Establishing the technical transfer-cooperation channel with Daegu Environmental Corporation (DEC), which has established and is running one of the best sewage treatment plants in the country, is expected to greatly contribute to the future enhancement of the water treatment capacity of Colombia. This has been confirmed through case studies and a field visit to DEC.

The efficiency of a water treatment management system can be achieved through the introduction of not only management know-how, but also high-efficiency, low-cost water treatment facilities and equipment. The water treatment facilities and equipment business of Colombia can be classified as poor local manufacturers, companies with joint investments with foreign advanced corporations, and simple importers. The technology transfer plan generated from the preliminary investigation through local networks and field visits suggests that the joint investment via the technical transfer-cooperation channel between companies of both nations will ultimately be the most effective. Specific technologies and products to be transferred have been confirmed through a demand survey in each nation and in a workshop between Korean companies and Colombian water treatment policy administrators.

A joint investment between companies would be the most effective model for the transfer of water treatment technology to the private sector of Colombia. A rather comprehensive connection would be necessary, such as through a private-public joint investment or EDCF or ODA projects, with establishment of a central organization for technical cooperation. The establishment of technology transfer plans to improve Colombia's water treatment capability is expected to contribute to the co-development of water treatment fields of each country in the long-term.

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