GREEN GROWTH IN ACTION

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03

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PROMOTING GREEN GROWTH THROUGH WATER RESOURCES MANAGEMENT: THE CASE OF REPUBLIC OF KOREA

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INTRODUCTION

Water is a multidimensional resource, which is obviously very important to humans and to the environment. Water security and water quality affect numerous economic sectors and areas: agriculture, energy, disaster management, and others. This multi-dimensional aspect makes water resources management complex, and countries need balanced and integrated approaches for water management that are economically, environmentally, and socially sustainable.

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Like many countries, Korea faces multiple water-related issues. A half century of rapid economic growth and urbanization created significant water management challenges, and Korea's climate and topography add to the complexity. Climate change has presented further threats to Korea's ability to secure and manage water supply. Rising sea levels and droughts degrade water quality, and climate change increases the frequency and severity of droughts and floods.

Korea's integrated water resources management approach, a key component of Korea's national economic development since the 1960's, has evolved in response to these issues. Korea's water management and policy initially focused on increasing water supply, generating hydropower, and decreasing flood damages to seek balance between environmental and development goals. The Korea Government faced continued pressure from increasing public demand for higher quality of life, cleaner environment, and preservation of natural resources. Korea's water management approach responded by shifting from a technical focus to be more adaptive, inclusive, and innovative. Korea's policies since the 1990s reflect a new "green" climate-resilient development path to Korean water management.

To deal with diverse water resources management issues and challenges, the Korean Government designed the "*Four Major River Restoration Project* (4MRRP)", a multi-purpose, green-growth infrastructure initiative to secure quality water resources, decrease droughts and floods, manage rivers, and improve the environment and Korean quality of life. The project involves five ministries and 78 local authorities, using a comprehensive and integrated approach. A key challenge is to implement large-scale infrastructure efficiently and effectively. This involves overcoming institutional, legislative, and governance issues, in addition to technical and financial hurdles, requiring innovative approaches to overcome. Collaboration and partnerships among key actors and stakeholders is critical. The 4MRRP, a key initiative that has broadened Korea's green growth outlook, showcases key lessons for successful operation of multipurpose "green" and sustainable water infrastructure projects.

Korea's water management approach responded by shifting from a technical focus to be more adaptive, inclusive, and innovative.

1. CHALLENGES FOR KOREAN WATER RESOURCES MANAGEMENT

WATER SECURITY

Water resources in Korea are extremely vulnerable due to the country's topography and climate. Korea experiences uneven rain throughout the year and some topographical features, such as rivers with short reaches and steep channel slopes, have contributed to frequent historical flooding. Annual rainfall is 1,277mm, higher than the world average of 807mm, but 70% of Korea's annual rain occurs in a concentrated timeframe, from June to September. Steep mountains in the Northwest and flat areas in the Southeast cause 74% of water to evaporate, encouraging floods and leading rainfall to flow directly into the ocean, leaving only 26% of rainfall available for use. Since Korea is densely populate, annual precipitation per capita is only 2,705m^3 only about 10% of the world average of 26,800m^3 per capita.

HYDROMET-RELATED DISASTERS

Korea's topographical and climate trigger major "hydromet-related" disasters, such as floods and droughts.

1. Droughts

Frequent droughts reduce the stability of Korean water supply. Eighteen droughts have occurred over the last 100 years, with severe droughts occurring in seven-year cycles since 1994 (see Table 1).

TABLE 1. DROUGHTS AND DAMAGES SINCE 1990S

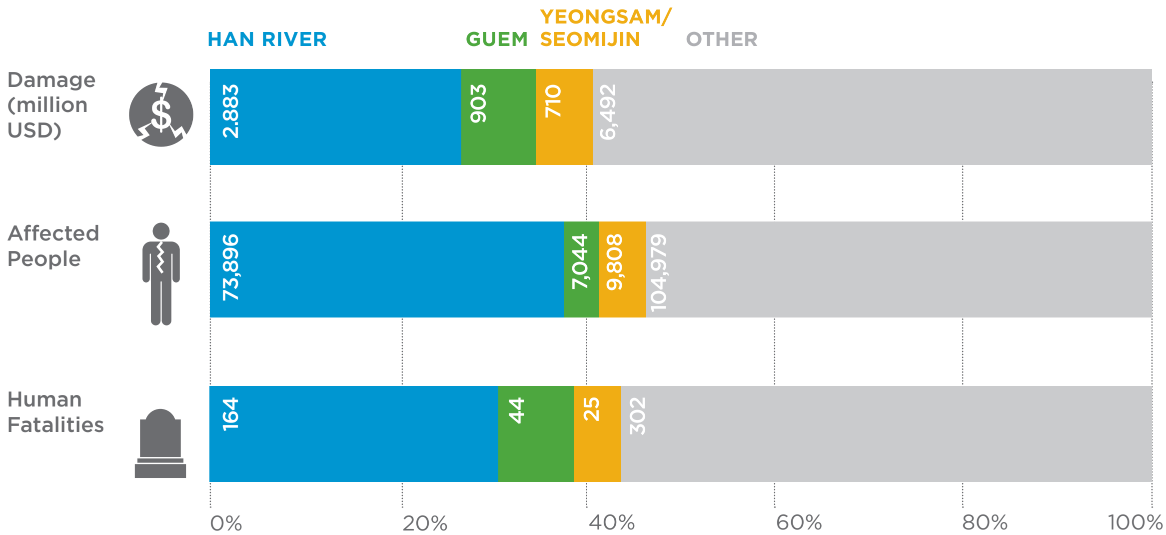
YEAR	DAMAGES
1994-1995	Limited water supply for 222,000 persons in 86 cities and counties
2001	Limited water supply for 304,815 persons in 86 cities and counties
2002	Limited water supply for 92,838 persons in 23 cities and counties
208-2009	Limited water supply for 228,068

Source: MLTM (Ministry of Land, Transport and Maritime Affairs). 2012b.

2. Floods

Due to intense summer downpours, floods in Korea are common with damages amounting to an annual average of about 1.5 billion USD (1.5 trillion KRW) over the last decade (see Figure 1). Short and steeply sloped rivers increase inland flood damage, contributing to accumulation of sediment of 30.5% in the four main riverbeds. Rapid flow and increased floods damage flood control facilities, making flood control more difficult.

FIGURE 1. KOREAN FLOOD DAMAGE OVER THE LAST DECADE



Source: MLTM 2012b.

Climate change increases disaster risks. According to the Intergovernmental Panel on Climate Change's (IPCC) 4th Assessment Report in 2007, global warming and climate change will increase the average temperature of the Earth by approximately 2-3.8 degrees Celsius; temperatures in East Asia will rise about 3.0 degrees. The rate of *evapotranspiration* will also increase, which will decrease water availability and threaten water security. Furthermore, floods and droughts are likely to become more frequent, unpredictable, and damaging. According to a report by the Korea Meteorological Administration, the number of days with heavy rain of over 80 mm or more in Korea increased from an annual average of 20 in 1952 to 51 in 2003.

Korea faces approximately 2.36 trillion USD in damages this century without a response to climate change. From 2061 to 2090, the frequency of droughts would multiply 3.4 times, while frequency of heavy rainfall (over 100 mm/day) would increase 2.7 times. Flood volumes would increase by 20%, testing the defense capability of dykes. Temperature rises by 2060 would cause a more than 33 billion ton-per-year water shortage for agricultural, domestic, and industrial use. Taking all of this evidence into account, Korea is in critical need of preventative countermeasures against droughts and floods.

WATER QUALITY

Maintaining adequate water flow for ecosystem maintenance is extremely difficult, especially during droughts. Besides droughts and floods, Korea water quality and river ecosystems have degraded. Point and non-point[1] pollution has increased due to rapid industrialization and urbanization, while illegal,

[1] *Pollutants enter the water environment from two main types of sources. A point source is a single, identifiable source of pollution such as a pipe or a drain. Industrial wastes commonly discharge to rivers and the sea in this way. Non-point sources of pollution, often termed "diffuse" pollution, refer to those inputs and impacts that occur over a wide area, and not easily attributed to a single source.*

unregulated agricultural practices pollute rivers. Non-point pollutant sources contribute approximately 68.3% of Korea's entire pollution (based on BOD in2010), and this is expected to increase to 72.1% by 2020 if impervious areas increase without management of non-point pollutant sources.

LACK OF PRESERVATION AND SYSTEMATIC USE OF WATER ENVIRONMENT

Repeated draughts and floods, which worsen under Climate Change, created significant environmental challenges in Korea, including ecosystem loss, habitat degradation, human causalities and displacement of river residents. As Korea's economy grew, people's water needs diversified to include recreation and ecosystem maintenance. Waterfront areas along rivers provide important public spaces for leisure, sports, tourism and education. Koreans wanted river-polluting agriculture facilities relocated, and they wanted the government to develop public spaces such as parks and bike paths.

2. OVERVIEW OF KOREA'S FOUR MAJOR RIVERS RESTORATION PROJECT (4MRRP)

Korea's hydrological characteristics—high concentration of annual rainfall over three months, high rainfall loss, uneven rain distribution, low annual precipitation per capita, droughts, and increase of incidents of heavy flood-causing rains, among others—contribute to complicate water resources management in Korea. These challenges will increase due to the impact of climate change.

To resolve a range of water-related issues, the Presidential Committee on Regional Development initiated the *Four Major Rivers Restoration Project* (4MRRP) as part of the "*Green New Deal Project*." Korea adopted "green growth" as a new economic growth paradigm to create a new engine of growth and stimulate job creation through "green" technology and "greening" of industries. The *Green New Deal Project* aims to redefine "progress" by simultaneously pursuing and balancing economic, environmental, and social development, including generating revenues and job opportunities.

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GOALS OF THE PROJECT

The goal of the 4MRRP was to restore South Korea's major rivers. By doing so, 4MRRP adapted water resources to resolve water and environmental challenges, including effects from climate change. The project had five core tasks:

i) **secure water;**

ii) **protect from floods;**

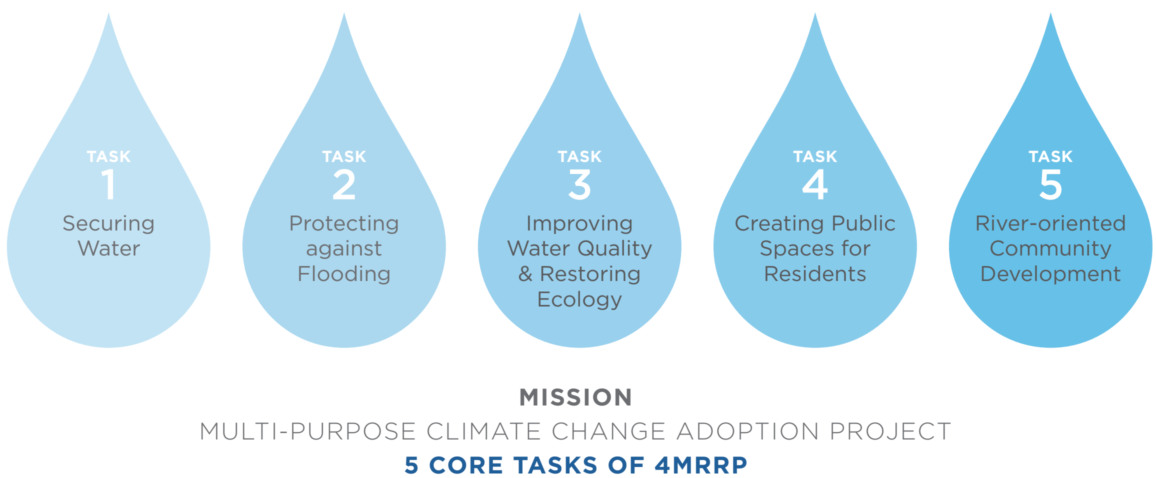
iii) **improve water quality and restoring ecology;**

iv) **create public spaces ;**

v) **promote river-oriented community development (see Figure 2).**

Task fifth task was part of Korea's broader Korean Government *Green New Deal Policy* initiated in 2009. The short-term objective of the green budget was to create economic stimulus and jobs during the global recession. Under the initiative, the government allocated a "green budget" of about 86 billion USD in total, equivalent to 2% of Korean annual GDP from 2009 to 2013. Out of this green budget, the government allocated about 20%, or 19.3 billion USD, for water-related tasks i, ii, and iii of the 4MRRP.

FIGURE 2. 5 CORE TASKS OF THE 4MRRP



Source: K-water. 2014.

SCOPE OF THE PROJECT

The 4MRRP targeted four major Korean rivers: the *Han, Nakdong, Geum*, and *Yeongsan* (see Figure 3). To achieve the 4MRRP goals, five core tasks covered the following goals (see Table2).

Secure water The 4MRRP secured an extra 1.17 billion of water, which largely mitigated the effects of droughts and water shortages. Building of 16 new moveable weirs, elevation of 93 agricultural reservoir banks, and construction of two small-to-medium-sized dams secured additional water storage for urban water supply, irrigation, and river environments.

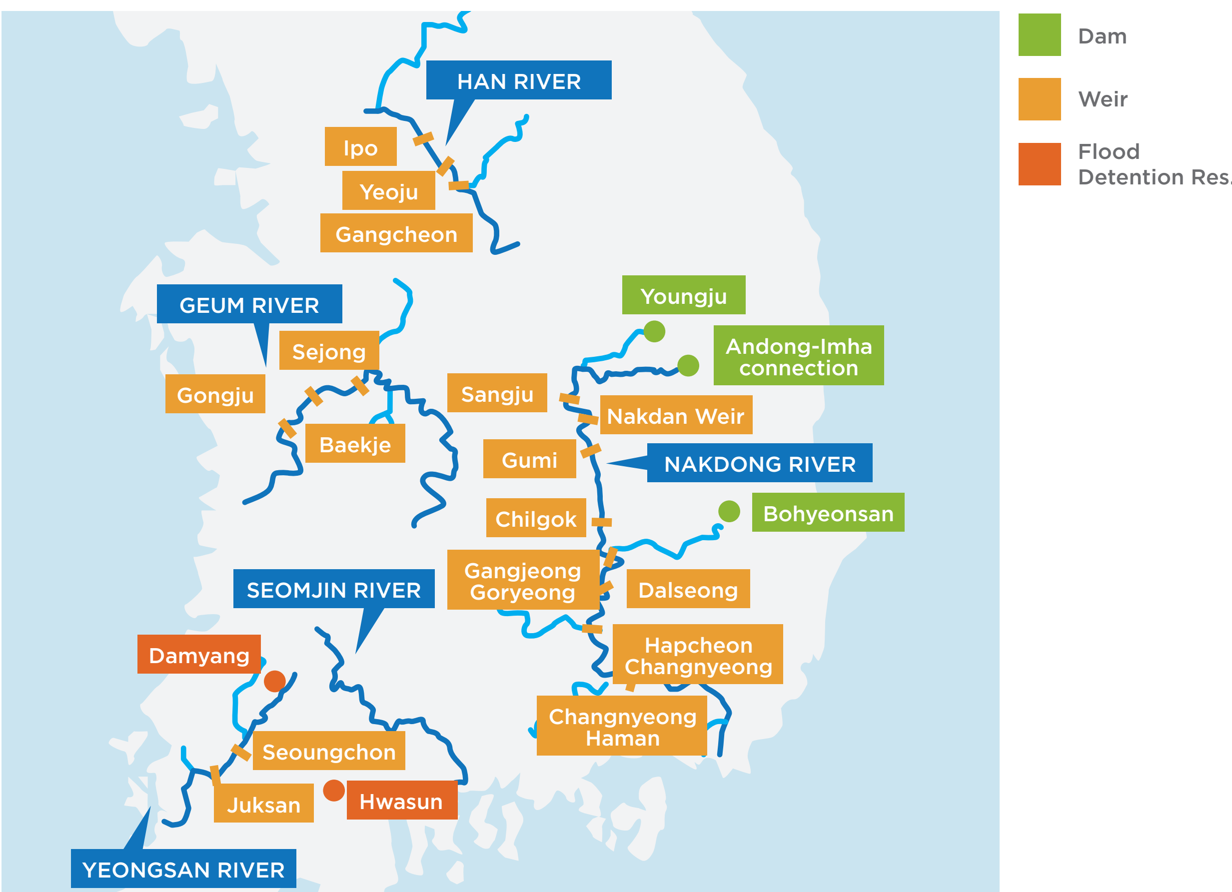
Protect against flooding Dredging 450 million of deposits and sediment along 530 kilometers widened and deepened waterways and secured flood-flow capacity for main rivers and tributaries at the once-in-200-year flood level. Also, 4MRRP work along 131 Km of levees on the Han River, 335km on the Nakdong River, 117km on the Geum River, 17km on the Yeongsan River, and 20km on the Seomjin River included levee reinforcement and reconstruction, and removal of steep bank slopes widened river channels. Use of green structures, such as soil and plants, created cultural and leisure spaces in sections deemed low risk for erosion. These comprehensive flood-control measures resulted securing in 920 million m^3 of flood storage capacity.

Improve water quality The project aimed to achieve the average of grade 2 of the national environmental criteria by 2012, Biochemical Oxygen Demand (BOD) level of 3 ppm or less. The project relocated farmlands and vinyl greenhouses away from rivers, and reinforced 207 wastewater treatment facilities, 589 sewage sites, 31 livestock excretion treatment facilities, 545 TP treatment facilities, and ecological reservoirs at 85 sites. The project also enlarged sewer pipes at 246 sites.

Restore Ecology Relocation of farmlands and vinyl greenhouses created 130 of new or renewed wetlands. Eco-friendly fish-ways installed near the new weirs helped restore natural fish migration patterns.

Promote river-oriented community development Waterfront development aimed to support regional economic development through job creation and local economic revitalization. Relocation of facilities also created space for public recreation infrastructure, such as bike paths, sport facilities, and campsites. Cultural Centers built near the four main rivers today help convey knowledge of regional history as well as raise awareness of the significance of the river restoration projects. There was strong socio-political will work behind the water environment restoration.

FIGURE 3. MAP OF 4MRRP



Source: K-water. 2012

TABLE 2. PROJECT SCOPES AND EFFECTS

Securing water	Movable weirs : 16 Dams : 2 Elevating agricultural reservoir banks : 93	**Secure 1.17 billion m^3**
Protecting against flooding	Dredging : 450 million Detentions : 5 places Reinforcing dilapidated levees : 784 km	**Lower flood water levels (2-4m)**
Improving water quality & restoring ecology	Wastewater treatment facilities: 207 Sewage sites: 589 Livestock excretion treatment facilities: 31 TP treatment facilities: 545 Ecological reservoirs: 85 sites Enlargement of sewer pipes: 246 sites	**Swimmable water 76% → 86%**
Creating public spaces for residents	Ecological wetlands : 11.8 million m^3 Fish-ways : 33 sites	**Improve natural ecology & promote eco-tourism**
River oriented community development	Bicycle paths : 1,757 km Sport facilities : 454 Campsites : 1,529 (camping car parking : 520) Cultural Centers : 5	**Better quality of life**
Job Creation	Job creation : 340,000 17.3 persons per 1 billion KRW investment are employed in construction business	**Enhance economic well-being**

Source: MLTM 2012b.

3. IMPLEMENTATION OF THE PROJECT: THE MAIN ELEMENTS

As seen in the objectives and the scope of the 4MRRP, the project is a massive, large-scale infrastructure project. For the success of such large investment projects, it is critical to establish a clear mechanism for planning, designing, administrating, operating, and financing, while maintaining room for innovation. We present some critical elements learned for successful multipurpose infrastructure project implementation below.

LEGISLATIVE SUPPORT OF THE 4MRRP

Three different ministries—Ministry of Land, Infrastructure and Transport (MOLIT),[2] Ministry of Environment (MoE), and Ministry of Agriculture, Forestry and Rural Affairs (MoAFRA)—were involved in the water project. They have different authorities and responsibilities: water quantity falls under MOLIT, water quality falls under MoE, and agriculture-related issues fall under MoAFRA. The Government enacted or amended a number of laws to implement the 4MRRP, which helped distribute project benefits widely and ensure sustainability of the massive project.

National Finance Act

The purpose of this Act was to establish a framework for financial management and sound fiscal operations. Legislators amended the Act to accelerate 4MRRP implementation by exempting disaster-risk management projects from preliminary feasibility studies.

Act on Contracts to which the State is a Party

The purpose of this Act is to promote smooth administration of contracts by State government organizations. Legislators amended the Act to spur local development by increasing the mandatory participation share for local construction companies in joint ventures.

Special Act on the Utilization of Waterfronts

The purpose of this Act is to prevent ill-conceived development and to promote sustainable growth by creating and using areas near national rivers. The Act promotes development of eco-friendly waterfront, and prevents unregulated development.

River Act (Charge Ministry: MLTM, now MOLIT)

The purpose of this Act is to manage rivers to increase benefits from river use, encourage nature-friendly maintenance and preservation of rivers, and to prevent damages from disasters. Amendment of the act allowed Korea Water Resources Corporation (K-water), a public water resources management company, to operate and maintain integrated facilities. Before the amendment, local governments retained responsibility.

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[2] *In 2013, the Ministry was reorganized and newly named as the Ministry of Land, Infrastructure and Transport from the Ministry of Land, Transport and Maritime Affairs.*

INSTITUTIONAL SETTINGS

A. Implementation coordination

Successful coordination among key stakeholders and organizations was a very important element to 4MRRP implementation. The project-based mechanism:

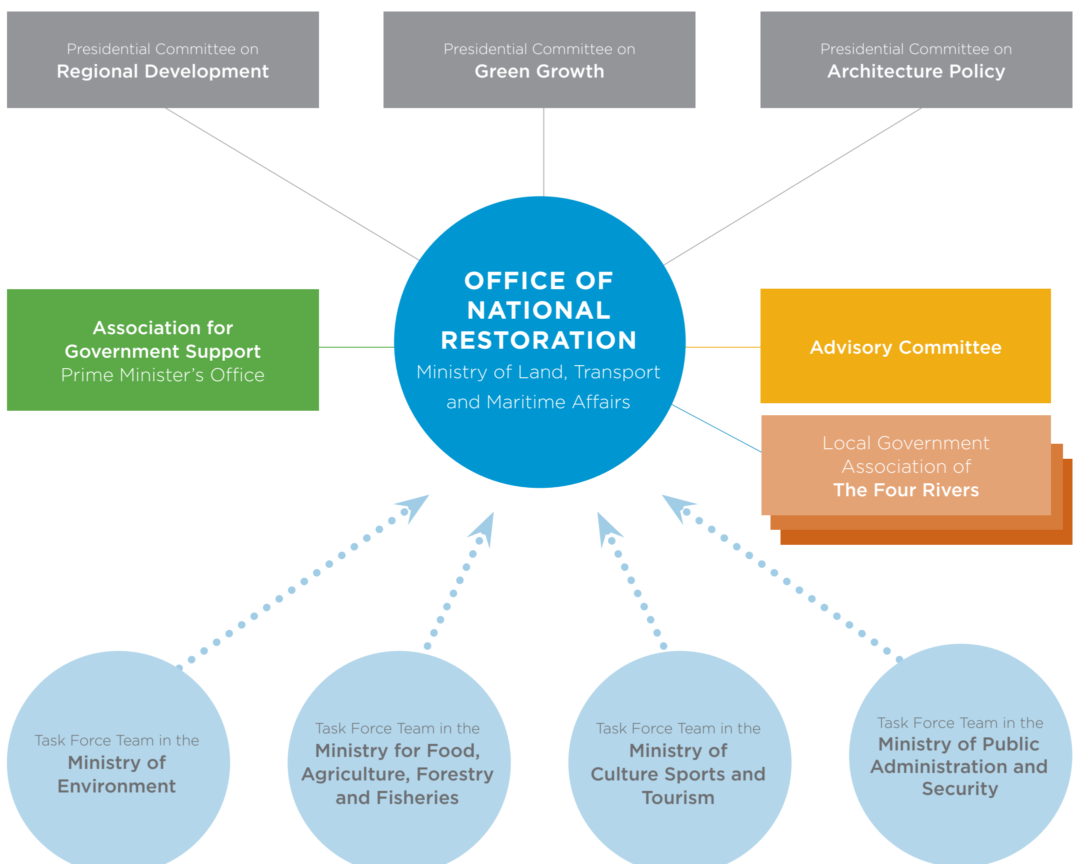
i) Coordinated various ministries and organizations at the national and river-basin level;

ii) Collected expert views from academia and research institutions; and

iii) Built project consensus among key stakeholders.

The government established the Office of National River Restoration under the Ministry of Land, Transport and Maritime Affairs. Different ministries and local government association of the four rivers connected through the Office of National River Restoration. In addition, an Advisory Committee—comprised of about 1,000 experts, academics, policy advisors, and community organizations, among others—helped guide the project. The committee played a crucial role in collecting expert opinions, building public support for the complex project, and enhancing the consistency, efficiency, and transparency of project decision making and implementation.

FIGURE 4. PROJECT ORGANIZATION STRUCTURE



Source: Republic of Korea, 2013

B. Stakeholder participation

The project established a governance system to encourage stakeholder participation.

A huge project such as the 4MRRP is bound to create social conflicts. The project presented controversial issues in areas such as modification of natural waterways, increasing weirs and their effects on water quality, dredging and its effects on ecosystems, and effects on cultural artifacts, among others. Some stakeholders questioned the reliability of environmental assessments, the suitability of processes, and budget allocation decisions. Conflicts over how the country should use and allocate its water resources added to complicated matrix of problems. The 4MRRP governance system had three main purposes:

- i) **Collect expert opinions to address technical issues and facilitate public consensus;**
- ii) **Allow stakeholder to participate in decision-making; and**
- iii) **Raise awareness of the benefits of the multipurpose project.**

C. Specialized water management agency

One of the important success factors of the 4MRRP was that a specialized water resource agency managed the project. K-water plays a crucial role in promoting both construction and operation of multi-purpose water facilities in Korea. The Korean Government founded K-Water in 1967 in accordance with the national development goals to develop heavy and chemical industries and facilitate modernization of the national industrial structure. The Ministry of Land, Infrastructure and Transport (MoLIT) regulates K-water. K-water brings experience and technology to provide Integrated Water Resources Management (IWRM) and construction, operation, and management of water resources facilities, such as dams, weirs, local water works and sewage facilities. K-water also builds industrial complexes and waterfront spaces, along with developing and applying renewable water energy sources. K-water oversees 95% of South Korea's flood control capacity, 65% of water supply capacity, and 63% of hydropower under a unique financial arrangement that combines government support with profit making.

K-Water served as operator and implementer under the 4MRRP to:

- i) **Coordinate among stakeholders and facilitate involvement;**
- ii) **Implement project components and onsite operation, including construction of large-scale multifunctional facilities and weirs;**
- iii) **Establish central control systems, including use of innovative technologies; and**
- iv) **Oversee the financial arrangement.**

KEY TECHNOLOGIES

K-Water developed innovative and integrated technologies to manage water resources. The management of rivers and adapting to changing characteristics requires river-basin level integration. K-water uses information communication technology (ICT) to optimize dam and weir operation to avoid water use conflicts among environment, flood control, and transport needs.

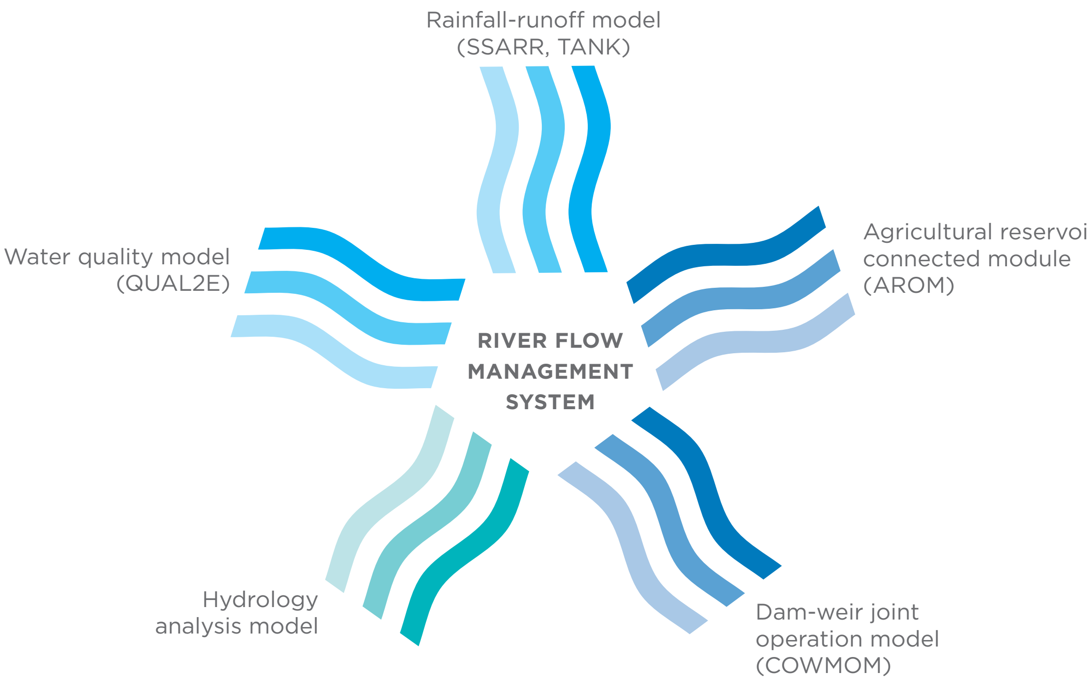
A. ICT-based data collection and monitoring

Use of converging state-of-the-art ICT technologies is central to river basin, real-time mobile data collection and monitoring. ICT applications, such as satellite weather forecasting, rainfall forecasting, and real-time floodgate information support weir-dam integration. The integrated operating system transmits and stores data for each weir, reservoir, and facility unit into an integrated database, allowing water quantity and quality predictions and facility use optimization.

B. Macro-analysis system for river flow management

K-water developed a macro-analysis system to support joint dam-weir river flow management and flood control. Operating these facilities requires analyzing a variety of monthly and daily hydro-meteorological conditions data, such as river and reservoir water quality and quantity. The system has five models: dam-weir joint operation, water quality, rainfall runoff, hydrology analysis, and an agricultural reservoir-connected model (see Figure 5). Integrating these models into one system enables operators to easily collect information, and perform real-time simulations of river discharges from weirs. Based on hydro-meteorological predictions, the operators control the quantity and quality of rivers (factoring for hydro-meteorological uncertainty).

FIGURE 5. MACRO-ANALYSIS SYSTEM FOR RIVER FLOW MANAGEMENT



Source: K-Water, 2012

ECONOMIC AND FINANCIAL ISSUES

Benefit-cost analysis Use of benefit-to-cost analysis, along with an analytic hierarchy process (AHP)[3] , helped examine ecological river restoration projects, bicycle path and dam construction, and agricultural reservoir rehabilitation. AHP, a decision-making method to help evaluate alternatives, enables evaluation where different levels of preference among multiple decision-making goals or evaluation criteria exist. Any project rated over "1" in benefit cost ratio (B/C), or over 0.5 for AHP, rates as worth implementing for the project. The B/C ratios of two multipurpose dams constructed rated 1.02 and 1.27. AHPs for all projects, including bicycle paths, agricultural reservoirs and ecological restorations rated over 0.50.

[3] *The analytic hierarchy process (AHP) is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.*

A. Cost sharing across ministries (total project cost)

The 4MRRP had numerous goals, including increasing domestic, industrial and agricultural water security, and improving flood control and environmental protection. Ministries in charge of these different areas shared construction costs accordingly.

TABLE 3. TOTAL COSTS OF 4MRPP SHARED AMONG MINISTRIES (BILLION USD)[4]

	2009	2010	2011	2012	Total
MLTM for flood control and water resource development	0.63	5.87	6.14	0.89	**13.5**
MIFAFF for agricultural reservoir	0.07	0.43	0.99	1.07	**2.6**
MOE for ecological river restoration	0.78	1.17	0.86	0.53	**3.3**
Total	**1.48**	**7.48**	**7.99**	**2.49**	**19.4**

Source: Special Committee on Budget and Accounts, 2011

B. The project investment scheme on flood damage prevention

The cost of this comprehensive preemptive disaster protection project was significantly lower than Korean historical costs for flood damage prevention and recovery. As can be seen from Table 4, the total investment cost for the 4MRRP is 13.5 billion USD was much smaller than the accumulated 2002 to 2006 damage, restoration, and protection costs for Korea[5]. This implies a very good benefit-cost for the 4MRRP.

TABLE 4. 4MRRP INVESTMENT COST (MOLIT ONLY) AND DAMAGE COSTS

TOTAL INVESTMENT	DAMAGE	RESTORATION	PROTECTION
MOLIT 13.5 billion USD[6]	12.1 billion USD (2.4 billion/year)	18.9 billion USD (3.8 billion/year)	4.9 billion USD (1 billion/year)

Source: K-water. 2014.

[4] *Average currency for each year, Economic Statics System (1USD is equivalent to 1279.91 KRW (2009), 11057.04 KRW (2010), 1108.19 KRW (2011), 1126.58 KRW (2012) http://ecos.bok.or.kr/*

[5] *Costs calculated based on flood simulation and historical damage data.*

[6] *Average currency from 2002 to 2006 (1USD is equivalent to 1113.52 KRW) http://ecos.bok.or.kr/*

B. Cost Recovery

K-water established a unique financial scheme for the 4MRRP, which recovers project investment from both government sources and from the private sector. The government provides some financial support, but K-water also earns revenue from sale of water and electricity provided by the multipurpose dams. The company also captures land value appreciation from the project by selling improved lands. These financial arrangements reflect a very innovative approach compared to usual financing where government allocates infrastructure construction budgets.

K-water invested 7.07 billion USD out of 13.5 billion USD for the 4MRRP, with the MLTM (now MOLIT) sharing the remainder of the investment cost. K-water will cover the investment from the following:

- **Gains from development of waterfront areas;**
- **Profit from water supply and hydropower generation from Yeongju and Bohyunsan dams (water tariff from municipalities: 10 – 45cents/m^3**
- **Government budgetary support for some shortfalls**
- **Support from government budget to subsidize loan interest.**

Korea maintained stable water supply to users near the four river basins, largely because of stored water in dams and weirs. Before the project, emergency downstream requests for water release had occurred 20 times over the past 10 years, but there have not been requests for water release since completion of the project.

4. 4MRRP PERFORMANCE

While only several years have passed since project completion, 4MRRP has already demonstrated results, as shown below.

TASK 1 SECURING WATER

The project resolved water shortages for domestic, industrial, and agricultural uses in most regions. A severe, record-breaking drought occurred in May and June 2012, when Korea experienced the highest temperature in record and the lowest nationwide rainfall since 1908. Thirty-one cities and counties suffered from water shortage. Over 4,898 hectares of agricultural land, and 5,160 people, required emergency water supply. Korea maintained stable water supply to users near the four river basins, largely because of stored water in dams and weirs (see Table 5). Before the project, emergency downstream requests for water release had occurred 20 times over the past 10 years, but there have not been requests for water release since completion of the project.

TABLE 5. EFFECTS ON SECURING WATER

Location	Current level elevation in meters	Before 4MRRP			After 4MRRP		
		Water level during drought	Water level during dry-season	Lowest water level observed	Water level during drought	Water level during dry-season	Lowest water level observed
Gancheon weir Han River	38.0	36.2	35.3	35.6	1.8 ↑	2.7 ↑	2.4 ↑
Changnyeong Hamahn weir Nakdong River	5.0	2.7	1.0	1.5	2.3 ↑	4.0 ↑	3.5 ↑
Baekje weir Geum River	4.2	2.7	2.4	2.6	1.5 ↑	1.8 ↑	1.6 ↑

Source: K-water. 2014.

TASK 2 PROTECTING AGAINST FLOODING

Facilities constructed for the 4MRRP substantially decreased flood damage. Many regions would have suffered floods from 2011 to 2012 without 4MRRP. The project strengthened land resources to protect them from natural disasters. After the project, flood risk reduced in 85.1% of basin lowlands, with 8.6% of these areas rendered completely free from risks. In total, flood risks decreased in 93.7% of basin lowlands.

Dredging led to a 2 to 4 m reduction of the water level in each river. Flood water levels in the Han, Nakdong, Geum, Seomjin and Youngsan rivers decreased by 5.8m, 4.0m, 1.6m and 1.2m respectively in 2013 (see Table 6). Flood damage costs decreased by about 821 million USD[7]. Estimated flood damage costs in the four major rivers during 2011 monsoon season of 8.52 million USD were less than one-tenth the damage costs caused by similar floods in 1998 (1.1 billion USD[8]) and 2006 (1.6 billion USD[9]).

[7] *Average currency in 2013 (1USD is equivalent to 1094.98) http://ecos.bok.or.kr/*
[8] *Average currency in 1998 (1USD is equivalent to 1403.18)*
[9] *Average currency in 2006 (1USD is equivalent to 955.34)*

TABLE 6. FLOOD CONTROL EFFECTS IN RIVERS BY DAMS 2013

Location		Rain Event	Rainfall (mm)	Flood control effect			Reduced damage (billion KR)
				Dam	Weir	Dams-Weirs	
Han River	Yeoju	12-17 July	128	3.2m	5.8m	5.8m	690
Nakdong River	Jindong	2-8 July	137	2.1m	4.0m	4.0m	170
Geum River	Guemnam	2-8 July	90	1.2m	1.6m	1.6m	-
Yeongsan River	Naju	2-8 July	225	1.2m	No Weirs	1.2m	30
Yeongsan River	Naju	2-8 July	252	No Dams	1.7m	1.7m	10

Source: K-water. 2014.

Figure 6 demonstrates 4MRRP improvements during the heavy 2011 rainfall year. Flooding in farmlands, households, and public facilities reduced significantly. The pictures show how 4MRRP protected parks in 2011 ("After" picture to the right) even though rainfall was as high as in the 2006 flood-affected year ("Before" picture to the left).

FIGURE 6. EFFECTS ON FLOODING BEFORE AND AFTER 4MRRP

BEFORE JULY, 2006

Rainfall during the rainy season (mm):
Dalseong 277, Youngcheon 244

AFTER JULY, 2011

Rainfall during the rainy season (mm):
Dalseong 290, Youngcheon 220

Source: K-water. 2014.

TASK 3: IMPROVING WATER QUALITY AND RESTORING ECOLOGY

Increased water allowed better maintenance of river flows, which improved the quality of water and ecosystems in river basins. Relocating farmlands (6,578 ha), and clearing deserted waste around the river (2,860,000 tons), significantly reduced pollutant flows into rivers and tributaries. Expansion of environmental infrastructure resulted in improved BOD level and reduced total-phosphorus TP (30 – 40%) for all major rivers. The project also created 147 wetlands representing 12,538,000 m^2. Wetlands promote biodiversity and add flood-control capacity. Thanks to ecological stream restoration projects, the government forecasts that water quality and biodiversity will continue to improve.

TASK 4: CREATING PUBLIC SPACES FOR RESIDENTS

Facilities along the rivers provide public recreation. Integrated with the national road system, bike paths along the rivers have promoted a biking culture (see Figure 7). Eco-parks, camping sites, landmarks, and other new public facilities are also popular. Five new, multifunction "Cultural Pavilions" provide space for public enjoyment of culture and arts, or for the public to hold meetings, seminars, lectures, and exhibitions. The spaces are easily accessible and intended to build appreciation for beauty and harmony between landscape, humans, and the environment.

FIGURE 7. BIKE PATHS AND WATERFRONT AREAS AFTER THE 4MRRP

Photo: K-Water

TASK 5: RIVER-ORIENTED COMMUNITY DEVELOPMENT

The 4MRRP created an estimated 88,400 jobs in 2009 and 2010, with 16,523 people directly employed and 71,877 indirectly employed. The employment effects amount to 7.37 trillion KRW for two years from 2009 to 2010. Increased cultural and tourism activities create even more jobs. Amendment of the *Act on Contracts to which the State is a Parity* increased the percentage of compulsory local joint contracts to more than 20%, and the participation of local companies in the project reached 37.5%. According to Construction and Economy Research Institute of Korea research, 4MRRP created 17.3 persons jobs per 1 billion KRW spent. In total, 4MRRP created 340,000 jobs, producing economic benefits of about 40 trillion KRW.

OTHER OUTCOMES

Micro hydropower plants installed on all weirs produce approximately 2.7 hundred million Kwh of green (clean) renewable energy each, enough to power 58,000 households for an entire year.

5. LESSONS LEARNED AND RECOMMENDATIONS TO DEVELOPING COUNTRIES

Korea's 4MRRP project shows that integrated water resources management can improve water resources management, restore ecosystems, and help manage disaster risks, including managing the many risks posed by climate change. The 4MRRP also has been an economic growth engine, stimulating local economic development and jobs. Lessons applicable to other countries include:

Preventive water resources management—as opposed to prior damage recovery modes—is necessary to mitigate risks and uncertainties, including the increased risks stemming from climate change.

Preemptive investment in the river system in Korea, such as 4MRRP, represents a major shift from post-disaster damage recovery approaches to preventive management. Total investment cost of the project amounts to Korean damage recovery costs for only five years. In other words, prevention is extremely cost-effective.

Water is a cross-cutting resource, requiring integrated water resources management.

Although ministries have different functions and jurisdictions, coordinating their efforts optimizes project implementation and operation. Along with ministries, various stakeholders from academia, the public sector, the private sector, and from civil society united under Korea's "4MRRP Promotion System". The system enables collection of expertise and data to enhance effectiveness of complex and challenging water and environment multipurpose projects.

Consensus building and full stakeholder participating in decision-making is essential.

It is necessary to raise public awareness and inform the public on project progress. Cooperative partnerships established in Korea involved politicians, experts, environmental organizations, local communities, and civil society organizations. These partnerships help negotiate conflicting needs and interests during the project.

The river basin is an appropriate unit for water management.

4MRRP shows that river basins can serve as the principal unit of measurement and operation for integrated water management. Coordinating the range of needs at the river-basin level can optimize facility benefits and planning coordination. The project improved all river channels in equal measure to increase flood-flow capacities across the river basins. Offices established at each river basin operate these facilities, collecting hydro-meteorological water quantity and quality data to share among basins.

Information and Communication Technology optimizes water resources management.

Korea uses Information and Communication Technology to operate dams and weirs and manage water supply and flood risks. Authorities can easily monitor, share, and store hydro-meteorological data and operate facilities using advanced Information and Communication Technology. Integrated simulation models use Information and Communication Technology to predict scenarios in water quantity and quality, and optimize operation of dams, weirs and other facilities.

Institutional setting to procure sustainable financing and public support is necessary.

It is impossible to implement projects without legal and institutional support and governance. Korea quickly completed the large-scale 4MRRP, and maximized the benefits from the project, by modifying laws to minimize duplication or excessive procedures that delay projects and increase budgets.

Water resources management for climate change adaption can foster green growth.

The negative effects of climate change on water affect a range of other areas—energy, disaster management, agriculture, and ecosystems, among others. 4MRRP shows that climate change adaptation for water can contribute to sustainable local economic development. The 4MRRP addressed climate change-related water challenges while creating jobs and generating clean energy.

A specialized water agency can promote multi-purpose infrastructure projects.

K-water played a crucial role in implementing 4MRRP on the "hard" construction side of the project, but also on the "soft" coordination aspects. Large projects face operational, management, infrastructure, and coordination challenges across various national and local government organizations and private companies. Korea's state company K-water's over 40 years of experience in building and managing multi-purpose facilities allowed the company to coordinate the wide range of inevitable stakeholders concerns. K-water is now operating facilities that coordinate multiple water-uses, and K-water built these facilities under the 4MRRP using innovative project financing that does not rely solely on government budget support. This success is the result of establishing, funding, and staffing of dedicated institutions with proper arrangements, appropriate legislation, and sufficient capacity to coordinate multi-stakeholders and to implement and manage water resources projects.

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ANNEX

Korea's water resources management policy transformation

THE HISTORY

To address innate geographic, and evolving challenges over time, water resources management strategy and policy in Korea has undergone several transformations. Effective water resources management supported Korea's rapid economic growth, despite difficult conditions. The "*Miracle of the Han River*" would not have been possible without successful water resources management. Since the 1960s, Korean water and development policies changed to suit the needs and contexts at different stages.

Water policy underwent four main stages: 1) quantity, 2) quality, 3) climate change adaptation, 4) Integrated Water Resources Management (IWRM). This section will explain how policy progressed through these stages since the 1950s.

1965–1990:

In 1965 Korea was able to escape absolute poverty, following exponential export-oriented growth. The Korean War from 1950 to 1953 had destroyed almost everything, with most infrastructure, including water supply networks, demolished. After the war, Korea was one of the poorest countries with the income per capita of 64 USD. Exacerbating these limitations, most water supply networks, built during the Japanese colonial period, were in North Korea.

Korea focused on construction of physical infrastructure to support economic growth. Water-related plans, laws, and organizations devised during this period—namely the *10-Year National Water Resources Plan* and *Department of Water Resources*—resolved fundamental water challenges, such as securing water and food supply. In 1967, the Government of Korea established the Korea Water Resources Department Corporation (now K-water, Korea Water Resources Corporation) as a specialized agency for water resources development.

The comprehensive 1970s river basin development plan formulated for the four major rivers—*Han, Nakdong, Geum* and *Yeongsan*—included construction of major domestic and agricultural water supply infrastructure: irrigation, hydropower, flood control, and multipurpose dams and facilities. The main purpose of this infrastructure was to secure water to support export-oriented growth industries, a trend that continued until the 1980s. The efforts reduced flood damage by half, increased service ratio of the water supply from 30% to 65%, and irrigated some 600,000 hectare of agricultural areas.

1991-2001:

By the 1990s, the construction of multipurpose dams halted. Rapid urbanization, which saw city dwellers increase from 13% of the South Korean population in 1945 to 78.5% in 1995, required more water treatment facilities. During this same period, the water service rate increased from 18% to 82.9%, which also implied an imminent need to expand sewerage facilities.

In 1991 public concerns over water quality came to a head when a factory accidentally spilled phenol into the Nakdong River, polluting drinking water in Daegu, Korea's 4th largest city. This incident marked a turning point for water policy in Korea, shifting the focus from water quantity to water quality. The government enacted and began to enforce stricter environmental standards, and the government established environmental committees to manage river quality at the river basin level.

2001–PRESENT:

Since the late 1990s, Korean water policy has undergone yet another major shift. No longer limited to water quality, the government has managed water resources in a sustainable manner that respects both human and environmental needs. The Korean public demands quality water, but policies now reflect a balanced approach to satisfy the three pillars of sustainable development: economy, environment, and society.

Fulfilling various water user demands will become even more complicated as water resources feel the effects of climate change. Korean water management is again evolving in response, as demonstrated in the *Four River Restoration Project (4MRRP)*.

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The Korean Green Growth Trust Fund (KGGTF)—a partnership between the World Bank Group (WBG) and the Republic of Korea)—promotes, creates, and communicates knowledge about Green Growth approaches and projects based on the real-world experience of policy makers and Green Growth technical practitioners in Korea. The KGGTF seeks to strengthen and expand the World Bank's green portfolio by sharing evidence-based practical knowledge with WBG staff, WBG client countries, and other interested parties. In partnership with the WBG, KGGTF activities disseminate knowledge and promote the creation of a green growth knowledge network to help WBG clients design, plan, and implement green growth strategies and investments.

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