Quality Infrastructure Investment

Japanese Case Studies

FUKUOKA CITY
Efficient Water Management

Tokyo Development Learning Center

PRESENTED BY WORLD BANK GROUP

The Government of Japan

QUALITY INFRASTRUCTURE INVESTMENT PARTNERSHIP

福岡市 FUKUOKA CITY

Quality Infrastructure Investment
Japanese Case Studies

Fukuoka City
Efficient Water Management

Paul Kriss, Haruka Miki-Imoto, Hiroshi Nishimaki, Takashi Riku

Tokyo Development Learning Center
PRESENTED BY WORLD BANK GROUP
The Government of Japan
QUALITY INFRASTRUCTURE INVESTMENT PARTNERSHIP
福岡市 FUKUOKA CITY

RIGHTS AND PERMISSIONS

ABOUT TOKYO DEVELOPMENT LEARNING CENTER (TDLC)

Launched in 2004 in partnership with the Government of Japan, the Tokyo Development Learning Center (TDLC) is a pivotal World Bank program housed under the Global Practice for Urban, Disaster Risk Management, Resilience and Land (GPURL). Located in the heart of Tokyo, TDLC serves as a global knowledge hub that aims to operationalize Japanese and global urban development knowledge, insights, and technical expertise to maximize development impact. TDLC operates through four core activities: Technical Deep Dives (TDDs), Operational Support, Insights and Publications, and the City Partnership Program (CPP). For more information, visit www.worldbank.org/tdlc

AUTHORS AND ACKNOWLEDGEMENTS

This case study was jointly developed by Paul Kriss (Lead Urban Specialist), Haruka Miki-Imoto (Operations Officer), Hiroshi Nishimaki (Senior Urban Consultant), and Takashi Riku (Consultant, Arthur D. Little).

This case study was requested by the Ministry of Finance (MoF) International Bureau and enriched by the contributions of the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) Policy Bureau from the government of Japan, and city officials from Fukuoka City. From Fukuoka City, we particularly thank Kazuhiro Kubota (Executive Director, International Affairs Department, General Affairs & Planning Bureau). We thank Arthur D. Little for supporting the analysis and providing insights.

The team also thanks Kiyoshi Kodera (Senior Advisor) for his thought-provoking reviews and heartful support. The team gratefully acknowledges peer reviews and inputs from the following World Bank Group colleagues: Clive G. Harris (Lead Infrastructure Specialist) and Marcel Ionescu-Heroiu (Senior Urban Development Specialist). The team thanks Masato Miyazaki (Special Representative for Japan) and Maitreyi B. Das (Practice Manager) for their advice and guidance. The team also thanks the guidance from Victor Mulas (Senior Urban Specialist and TDLC Team Lead) and the collaboration and support from the Quality Infrastructure Investment (QII) Trust Fund team, Darwin Marcelo (Senior Infrastructure Specialist), Clive G. Harris (Lead Infrastructure Specialist), and Naomitsu Nakagawa (Program Officer).

This case study could not have been completed without generous support from the government of Japan to the TDLC Program..

DISCLAIMER AND CONTEXT

This case study builds on the G20 Principles for Quality Infrastructure Investment (QII) adopted at the Osaka Summit 2019. It is the first attempt to showcase examples where QII has been operationalized in urban infrastructure projects in Japan. In principle, the case study leverages existing data and evaluations available either in existing literature or through interviews with cities and public organizations.

World Bank Tokyo Development Learning Center (TDLC) works extensively in areas such as urban infrastructure and urban service delivery and, therefore, it has a ready stock of documentations in the urban sector produced during Phase III (2016 to 2020) of the TDLC Program. To prepare input for the G20 Infrastructure Working Group, the project team reviewed the compiled documents and reclassified the contents through the lens of QII.

The team selected this case on the basis of a rigorous review of studies accumulated by TDLC. The key selection criterion was whether the case appropriately highlights the operationalization of QII Principle 2 "Economic Efficiency" and Principle 6 "Infrastructure Governance."

The case study highlights how the selected Japanese cities have operationalized quality aspects in urban infrastructure. Detailed impact evaluation is not included in the scope of this case study; however, it is an area for future works to address.

CONTENTS

EXECUTIVE SUMMARY	**VII**
IMPLICATIONS FOR EMERGING ECONOMIES	**VIII**
Conceptual Takeaways	VIII
Technical Takeaways	VIII
1 INTRODUCTION	**1**
1.1 Fukuoka City – A Rising Star	1
1.2 Infrastructure as a Foundation for a Unique Growth Strategy	3
BOX Growth Led by Cutting_edge Industries and Start-ups	4
2 QII-2: LIFE-CYCLE COSTING FOR EFFICIENT WATER MANAGEMENT	**5**
2.1 Water Conscious City	5
2.2 Life Extension of Distribution Pipes	6
2.3 Water Distribution Control Center and Leakage Reduction Measures	6
2.4 Complementary Interventions	8
2.4.1 Water Reclamation	8
2.4.2 Usage-based Tariffs	9
2.4.3 Public Awareness Campaigns	10
3 QII-6: COMPREHENSIVE EVALUATION FOR TECHNICAL QUALITY	**11**
3.1 Introduction of Comprehensive Evaluation	11
3.2 Benefits and Methods of Comprehensive Evaluation	11
REFERENCES	**15**
END NOTES	**17**

BOX and FIGURES

Box: Growth Led by Cutting-Edge Industries and Start-ups 4

Figure 1.1 Location of Fukuoka City 1

Figure 1.2 GDP per capita and Annual Revenue of Designated Major Cities 1

Figure 1.3 Population of Fukuoka City 2

Figure 1.4 Number of Companies Attracted and Jobs Created 2

Figure 1.5 Number of Companies Attracted in Growing Industries 2

Figure 1.6 Start-up Ratio 2

Figure 1.7 Housing Rent in Fukuoka City and Tokyo 3

Figure 1.8 Liveability of Fukuoka City 3

Figure 2.1 Key Initiatives for Leakage Reduction 5

Figure 2.2 Overview of Water Distribution Control Center 7

Figure 2.3 Reclaimed Water Service Area 9

Figure 2.4 Water Reclamation Capacity and Number of Customers 9

Figure 2.5 Water Tariff System in Fukuoka City 10

Figure 3.1 Application of Comprehensive Evaluation by Number of Projects and Project Value 11

Figure 3.2 Application of Comprehensive Evaluation by Evaluation Type 13

Figure 3.3 Effect of Comprehensive Evaluation on Overall Performance of Public Works 14

TABLES

Table 2.1 Reduction of Pipe Replacement Costs with Polyethylene Sleeves 6

Table 2.2 Summary of Costs and Economic Evaluation of Key Initiatives 8

Table 3.1 Evaluation Criteria and Score Allocation by Evaluation Type 12

EXECUTIVE SUMMARY

Fukuoka City is one of the most prominent cities in Japan today. The city's liveability standards and competitiveness are attracting people and businesses despite the national trend of an aging and declining population and a stagnant economy. The city's population is growing at about 1 percent per annum, which is rivalled only by a few other major cities. The city attracts about 50 companies and 2,000 jobs per year in growing industries. Historically being the gateway connecting Japan and nearby Asian cities, Fukuoka City quickly shifted from a postwar growth model led by heavy industries to a modern growth model led by the service sector. By combining national policies, deregulation, targeted subsidies, and ecosystem-building initiatives, Fukuoka City became a rising hub for cutting-edge industries and, more recently, start-ups. Today, citizens enjoy a modern lifestyle with highly liveable environments in close proximity to their workplaces.

Early consolidation of basic infrastructure was key for Fukuoka City's sustained growth. In the 1970s, while many other municipalities adopted pro-development policies and expanded urban boundaries, Fukuoka City focused on creating compact urban cores with high-quality basic infrastructure. The city rigidly practiced the revised City Planning Law to control excess development in suburban areas and made up-front investments in infrastructure, removing potential obstacles for future growth. In particular, the scarcity of water resources was a major bottleneck for the city. Being the only major city in Japan without a Class A river system, Fukuoka City went to great lengths to secure water sources and to control water demand. Their efforts were further strengthened after a severe drought in 1978.

Life-cycle costing is the underlying principle for Fukuoka City's efficient water management. In 1979, Fukuoka City set out a vision to become a water-conscious City. Accordingly, the city undertook multiple investments to reduce operating expenditures and delay future capital expenditures in the water sector. The city revised its procurement policy to require polyethylene sleeves covering all new distribution pipes. The sleeves extend the pipes' lifespan by 40 years with an additional cost of 1–2 percent. Furthermore, the city established a Water Distribution Control Center and launched a leakage reduction program. As a result of these efforts, Fukuoka City reduced the water leakage rate from 14 percent in 1979 to 2 percent by the mid-2000s. The internal rate of return for the Water Distribution Control Center and leakage reduction program combined is estimated at 15 percent. Fukuoka City also constructed water reclamation facilities, introduced usage-based tariffs, and conducted public awareness campaigns as complementary interventions, which delayed future capital expenditures by suppressing the increase in water demand.

Comprehensive evaluation improved overall performance of public works. As Fukuoka City became a pioneer of life-cycle costing in Japan, resource constraints cultivated a commitment to quality within the city. The introduction of a comprehensive evaluation method to large investment projects institutionalized this commitment; Fukuoka City experimentally introduced this method in 2006 and gradually expanded the scope to include more projects. Today, in principle, comprehensive evaluation is applied to all projects over 100 million Japanese yen (¥), about 100 projects every year. The expected benefits of comprehensive evaluation include improvements in the technical quality of public works, incentivization of private companies to enhance their technical capabilities, avoidance of the use of lotteries when multiple firms bid the same price, and prevention of collusive pre-agreements among bidders. A key outcome is an improvement in overall performance of public works. A comparison of postevaluation results shows that projects are scoring higher after the introduction of comprehensive evaluation, particularly for large-scale projects.

Implications for Emerging Economies

Conceptual Takeaways

For sustained growth, cities should do the following:

- Identify bottlenecks for growth and clear them through early consolidation of basic infrastructure:
    - o When cities fail to do so, the unattended bottleneck will hamper growth at some point in the future.
    - o This approach is particularly important for cities that are about to or have just entered a rapid growth period because it allows them to minimize future adverse effects of rapid urbanization
- Identify and attract next-generation growth industries and invest in talent:
    - o Cities must capture future sources of growth to maintain momentum for the next few decades.
    - o A city's competitiveness is equivalent to talent retained, and people are attracted to liveable environments. Investing in talented people and their livelihoods is essential for future growth.

Technical Takeaways

For sustained growth, cities should do the following:

- Upgrading pipes with polyethylene sleeves is a cost-effective method to reduce replacement costs because polyethylene sleeves can significantly extend the lifespan of pipes with marginal additional costs.
- Investments for leakage reduction can contribute significantly to cost reduction:
    - o Capital expenditures that lower leakage rates can reduce water production and delivery costs, thus reducing the operational expenditures in the long run.
    - o Multiple investment options are available depending on the situation of the particular country.

1. INTRODUCTION

1.1 Fukuoka City – A Rising Star

Fukuoka City has a population of 1.6 million, ranking fifth among Japanese cities excluding Tokyo (Higashide 2020), and is one of the 20 government-designated major cities. The city is located in the northern part of the island of Kyushu, which is only 1–2 hours by plane from Tokyo; Shanghai, China; and Seoul, Republic of Korea (Figure1.1). Leveraging this geographical advantage, the city has historically been the gateway connecting Japan and nearby Asian cities.

Fukuoka City is one of Japan's most prominent cities even among the 20 designated major cities (Figure 1.2). The city's GDP per capita is 5 million Japanese yen (¥), ranking third among designated cities. (Fukuoka City 2020a). The city's annual revenue is ¥858 billion, ranking fifth among designated cities. (Ministry of Internal Affairs and Communications 2018).

FIGURE 1.1
Location of Fukuoka City

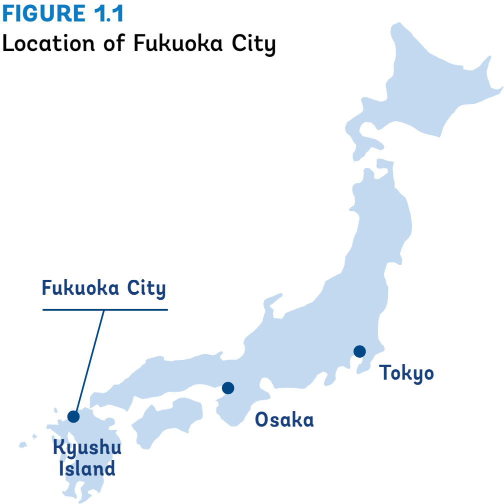
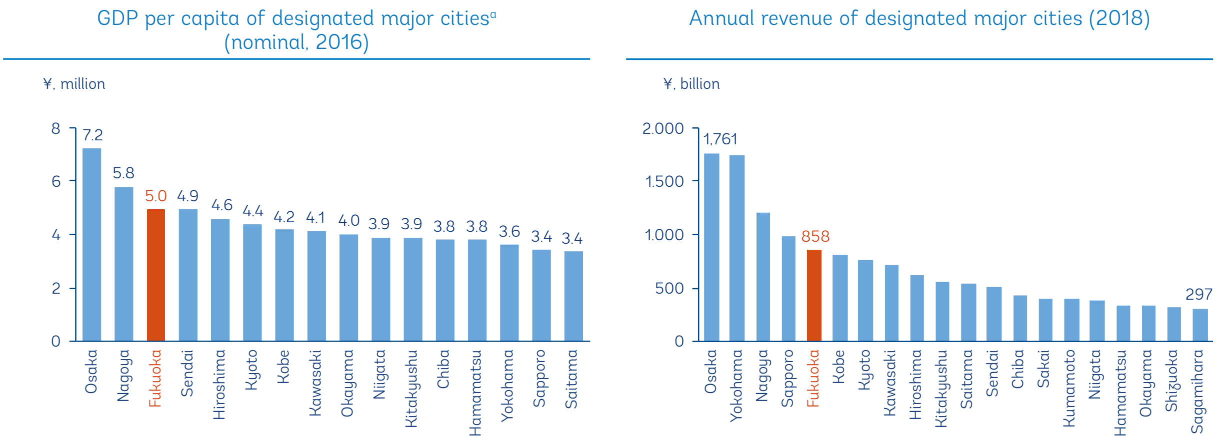


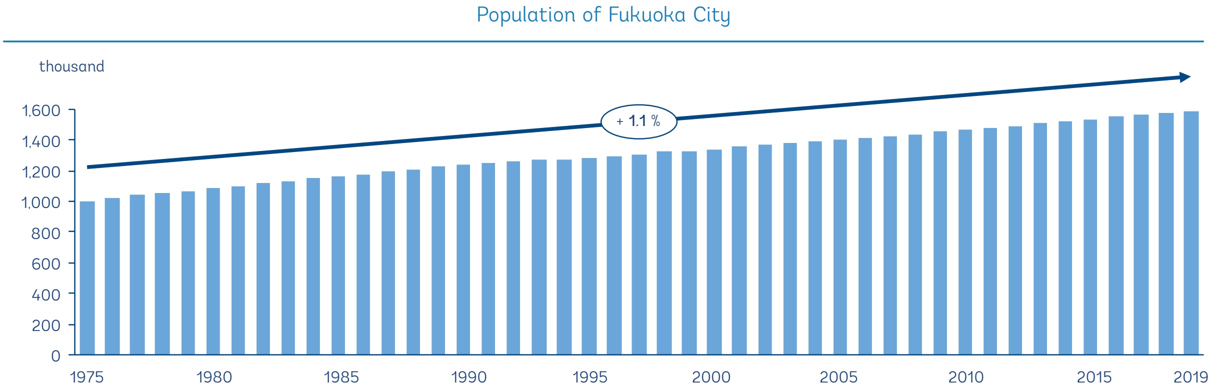
FIGURE 1.2
GDP per capita and Annual Revenue of Designated Major Cities



Source: Fukuoka City; Ministry of Internal Affairs and Communications.
a. Sagamihara, Shizuoka, Sakai, and Kumamoto are not included.

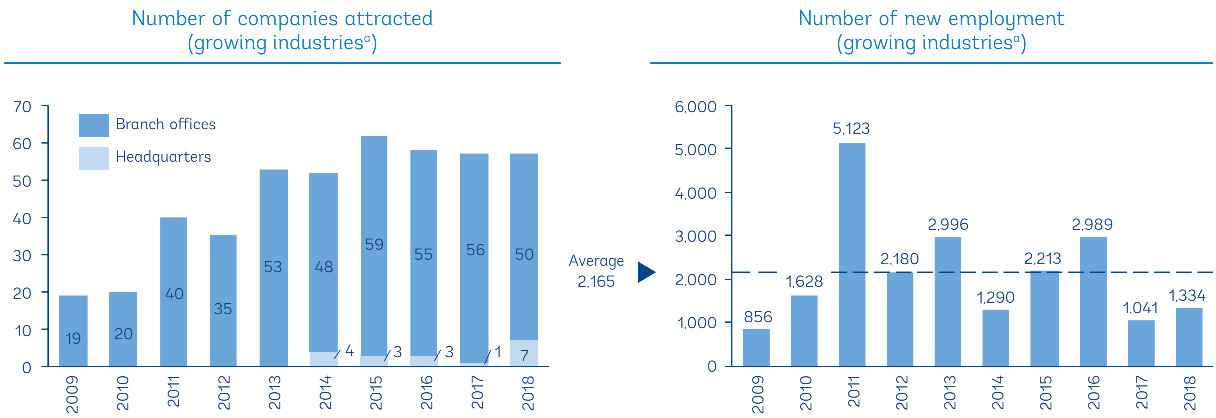
Despite the national trend of population ageing and decline, Fukuoka City's population is steadily growing at about 1.1 percent per annum (Fukuoka City 2019b; Figure 1.3). The city attracts businesses as well. Recently, approximately 50 companies in growing industries have opened offices in Fukuoka City each year. These companies bring about 2,000 jobs to Fukuoka City each year (Figure 1.4). The key growth drivers are the rapidly growing creative industries and start-ups. Of the 50 companies creating offices in Fukuoka City each year, an increasing number are from the creative industries (Fukuoka City 2019a; Figure 1.5). The city's start-up ratio has been about 7 percent over the past few years, which is well beyond the national average (Figure 1.6) and the highest among major cities (Fukuoka City 2020a).

FIGURE 1.3
Population of Fukuoka City



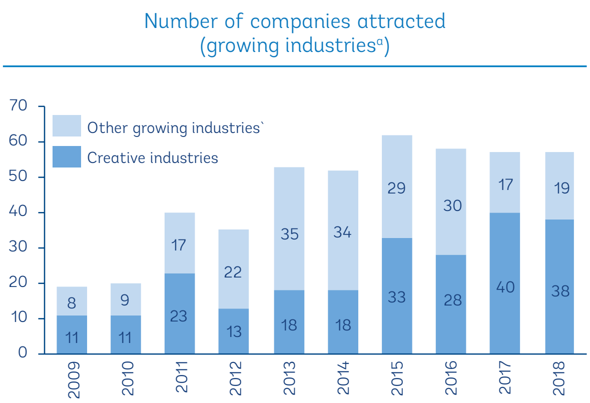
Source: Fukuoka City; National Census.

FIGURE 1.4
Number of Companies Attracted and Jobs Created



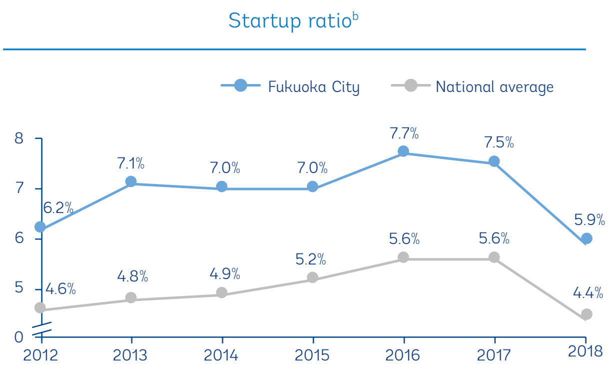
Source: Fukuoka City.
a. "Growing Industries" refers to creative industries, call centers, healthcare and welfare, environment and energy, logistics, and others

FIGURE 1.5
Number of Companies Attracted in Growing Industries



Source: Fukuoka City;
a. "Growing Industries" refers to creative industries, call centers, healthcare and welfare, environment and energy, logistics, and others.

FIGURE 1.6
Startup Ratio



Source: Fukuoka City;
b. Percentage of new companies among existing companies.

People and businesses would not be as attracted to Fukuoka City if not for its compact and liveable environment. After arriving at the airport, visitors can reach the city center in just five minutes. In fact, the airport, two central stations (Hakata Station and Tenjin Station), and the bayside area are all within a 2.5 kilometer-radius (Fukuoka City 2018a). Moreover, the cost of living is lower than other metropolitan areas. For example, the housing rent is 40 percent lower compared to that in Tokyo (Fukuoka City 2020b; Figure 1.7). In 2016, Monocle ranked Fukuoka City as the seventh most liveable city in the world. A survey in 2019 showed that 95.4 percent of the city's citizens considered their city as liveable (Fukuoka City 2019g; Figure 1.8).

FIGURE 1.7
Housing Rent in Fukuoka and Tokyo

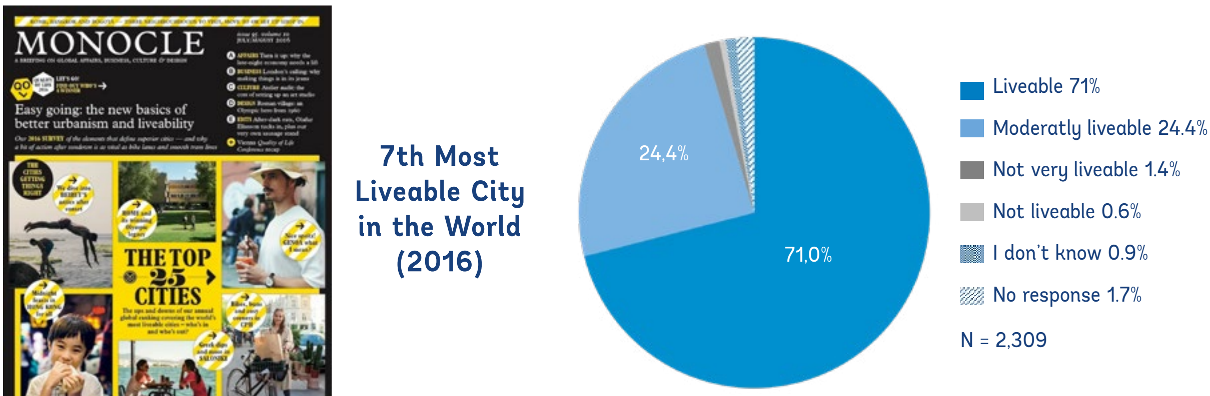
Fukuoka (Airport Metro –JR Chikuhi Line)	Tenjin	Akasaka	Ohori Koen	Nishijin	Meino-hama	Shimo-yamato
	128	155	128	115	88	56
	0 min		5 min	10 min	15 min	20 min
Tokyo (Tokyu Denentoshi Line)	Shibuya	Ikejiri-ohashi	Sangen-chaya	Komazawa-Daigaku	Yoga	Futako-shinchi
	365	260	201	187	175	124

Approx. 40% Lower

All rent values are in ¥, thousand

Source: HOME'S website (as of June 2018)

FIGURE 1.8
Liveability of Fukuoka City



Note: Total number of respondents is 2,309

1.2 Infrastructure as a Foundation for a Unique Growth Strategy

After World War II, Fukuoka City took a unique approach to economic growth compared to other cities. While many cities in Japan aggressively expanded urban boundaries and invested in heavy industries as the main driver of growth, Fukuoka City focused on consolidating basic infrastructure within a limited area to create a high-quality urban core. By doing so, the city not only avoided the pitfalls of rushed development such as heavy pollution, sprawl, and congestion, but also succeeded in retaining talent and attracting growth industries in the service sector (Diamond Online 2018).

Fukuoka City created its first comprehensive development plan in 1961, but this plan was still inclined toward industrial development. In 1966, the city announced the second plan, which downsized its commitment to heavy industries and prioritized the service sector. In 1968, a major revision to the national City Planning Law required Japanese cities to designate Urbanization Promotion Areas and Urbanization Control Areas. Fukuoka City quickly made the designation in 1970 to ensure orderly development amid a growing population. This mindset was reflected in the third plan created in 1971. This plan envisioned a "Functional, Beautiful, and Human-centric Urban Core," promising investments in basic infrastructure to improve living environments. In particular, the city focused on transport infrastructure such as the highway and metropolitan networks in the 1970s. In the fourth plan, created in 1977, "a city with a control mechanism" became a key concept. Since then, the city has strictly controlled development activities, particularly in suburban areas, by using city planning instruments such as the Development Permit system (Ishibashi and Shibata 2014).

Although Fukuoka City's early investments in basic infrastructure spanned multiple sectors, securing sufficient water resources was the obvious bottleneck for sustained growth in the long run. Being the only major city in Japan without a Class A river system[1], Fukuoka City simply lacked sufficient water to satisfy an ever-growing demand. This issue became all the more apparent in 1978 when the city suffered from a severe drought. In this year, the annual precipitation was 1,138 millimeters, which is only half that of a typical year. The city had to suspend normal water supply for 287 consecutive days. On average, citizens had access to water supply for only 10 hours per day (Fukuoka City 2009). This event pushed water management up the city's list of priorities. In 1983, Fukuoka City drew water from Chikugo River, which runs outside the city boundary and crosses three other prefectures. Aside from enlarging the water source, the city launched multiple initiatives to efficiently manage the available water resources. Details will be explained in the following sections.

BOX: Growth Led by Cutting-Edge Industries and Start-ups

Over the past few decades, Fukuoka City attracted companies in cutting-edge industries such as automotives, semiconductors, and biotechnology. Eligible companies are able to receive subsidies of up to 8 percent of the investment amount and tax exemptions such as property tax. Key industrial projects in the city (Fukuoka Prefecture 2020) include the following:

- Green Asia International Strategic Comprehensive Special Zone (National Project)
- Northern Kyushu Automotive Industry Asia Advanced Hub Project (Local Project)
- Advanced Semiconductor Research and Development Hub Project (Local Project)
- Fukuoka Bio Valley Project (Local Project)

Recently, Fukuoka City is quickly becoming a start-up hub. In 2012, Mayor Soichiro Takashima set out a vision for Fukuoka City to become a "Start-up City." In 2014, the Cabinet Office of Japan designated Fukuoka City as a National Strategic Special Zone for Global Start-ups and Job Creation. Since then, the city launched multiple projects to encourage citizens to start a company and to attract start-ups from within and outside Japan. A symbolic project was the revival of a closed elementary school as the start-up incubation facility Fukuoka Growth Next (FGN), which provides entrepreneurs with physical space and mentoring. The city also provides tax exemptions and visa requirement relaxations to encourage the youth and foreign populations to start their own businesses in the city. By combining national policies, deregulation, subsidies, and an ecosystem approach, Fukuoka City is quickly gaining recognition as a start-up hub. In fact, at FGN, more than 30 start-ups have raised over ¥8 billion in total as of 2019 (Gentosha Gold Online 2019).

2. QII-2: Life-cycle Costing for Efficient Water Management

2.1 Water Conscious City

In 1979, a year after the drought, Fukuoka City set out a vision to become a water-conscious city. Accordingly, the city launched multiple initiatives to construct an efficient water management system. In particular, the following were the three major initiatives for the city's transformation:

- Development and upgrading of water distribution pipe network
- Establishment of water distribution control center
- Leakage reduction measures

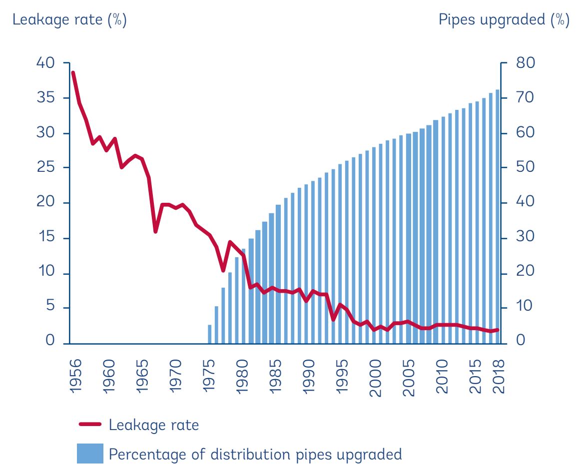
A key outcome of these initiatives is the extremely low rate of water leakage. Basic investments in water-related infrastructure reduced the leakage rate from nearly 40 percent in 1956 to about 14 percent in 1979. Fukuoka City made additional investments in these three initiatives and reduced the leakage rate to 2 percent by 2000 (Fukuoka City 2020d; Figure 2.1). This number is the lowest in the world and shows the city's strong commitment to saving water.

Furthermore, Fukuoka City worked on complementary interventions to control water demand. Specifically, the city built water reclamation facilities to purify and reuse sewage water for toilets and sprinklers, introduced usage-based tariffs to incentivize water-saving behaviors, and strengthened public awareness campaigns to instill a water-saving mindset among citizens.

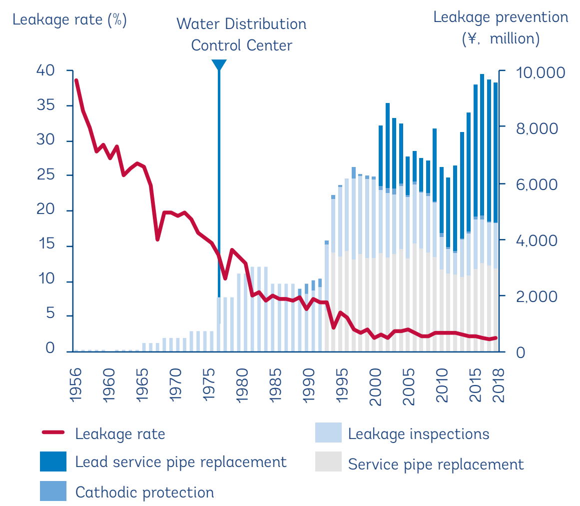
A key takeaway from this section is that life-cycle costing was the underlying principle in Fukuoka City's efforts to become a water-conscious city. The policy objective was to make full use of existing scarce water resources through efficient water management and demand control. This objective was achieved by making up-front additional investments in infrastructure to reduce operating expenditures and delay future capital expenditures. Although this aspect of life-cycle costing is not always explicitly mentioned in city records from the early years, Fukuoka City undoubtedly pioneered life-cycle costing in Japan.

FIGURE 2.1
Key Initiatives for Leakage Reduction

Leakage rate versus distribution pipes upgraded



Leakage rate versus leakage prevention works



Source: Fukuoka City.

As a fiscal background, one should note that most of the capital expenditures for the previously mentioned initiatives were financed by municipal bonds. In Japan, a city's water supply operation is self-sustaining in principle. In other words, the water tariffs should cover operational expenditures plus depreciation of invested assets. Fukuoka City's Water Distribution Control Center, which required a large initial investment, was indeed financed by municipal bonds.

2.2. Life Extension of Distribution Pipes

Fukuoka City continosly expanded their water distribution pipe network to cope with urbanization. The total pipe length grew from 624 kilometers (km) in 1965 to 4,024 km in 2018. True to its commitment to minimize water leakage, the city adopted high-quality specifications for its distribution pipes. At present, 99.9 percent of distribution pipes are made of ductile iron, which is a highly durable material that should last 60 to 80 years (Fukuoka City 2020c).

TABLE 2.1
Reduction of Pipe Replacement Costs with Polyethylene Sleeves

Items	Standard pipes	Pipes with polyethylene sleeves
Investment cost(relative, percent)	100%	102%
Pipe lifespan (years)	40 years	80 years
Net present value of replacement costs (5% discount)	117%	104%

Furthermore, in 1979, the city revised its procurement policy to require polyethylene sleeves for all newly installed pipes. The sleeves extend the pipes' lifespan by 40 years with an additional upfront cost of 1–2 percent. With no future changes in the pipe network and in comparison to a standard pipe with a lifespan of 40 years, equipping the pipes with polyethylene sleeves should reduce pipe replacement costs by half each year. As a result, this decision led to an approximately 13 percent reduction in the net present value of pipe replacement costs. (Table 2.1) In Fukuoka City, 3,000 km, or 75 percent, of distribution pipes are protected by polyethylene sleeves (Fukuoka City 2017).

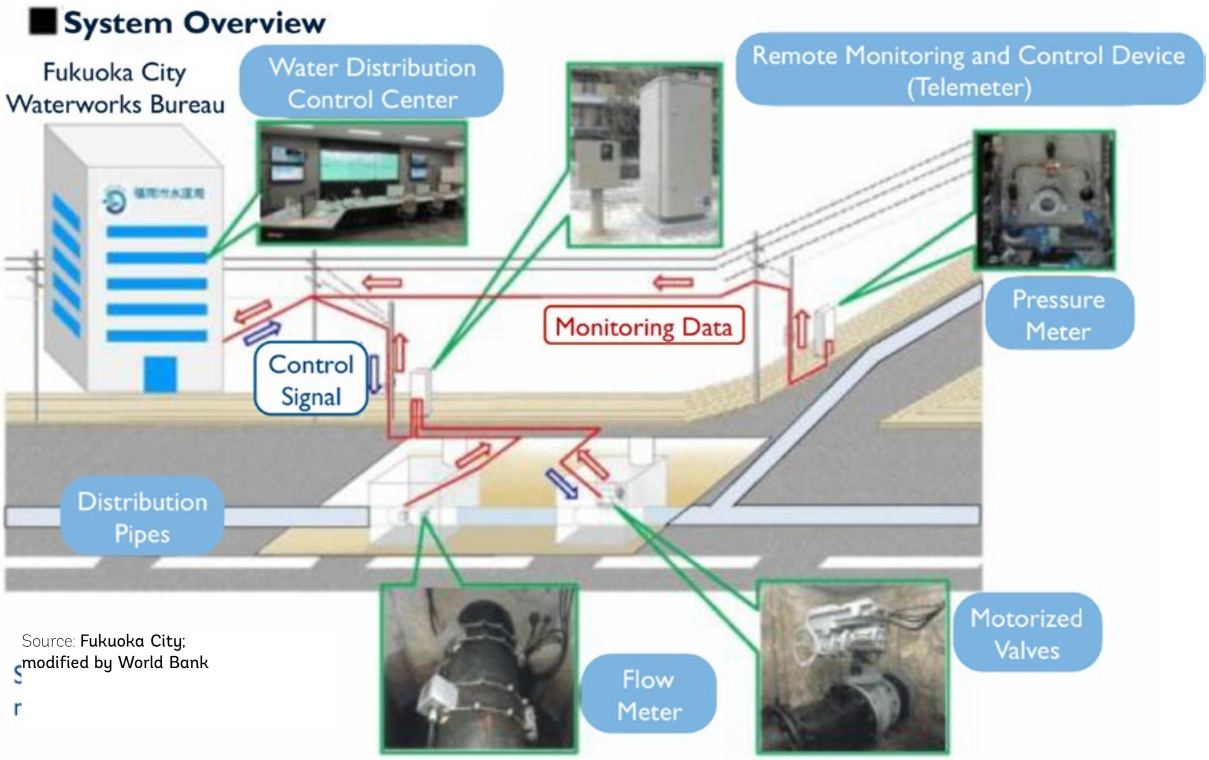
2.3 Water Distribution Control Center and Leakage Reduction Measures

In 1981, Fukuoka City established the Water Distribution Control Center. The center allows the real-time monitoring and control of water flow and pressure over the city's entire distribution pipe network. The center has the following functions:

- Integrated management of multiple purification plants by controlling water flow
- Leakage reduction by controlling water pressure
- Labor savings by remotely controlling valves
- Early detection and response to breakdowns through remote monitoring and control
- Feedback on water management through data collection and analysis

Within the control system, the city's entire water distribution network is divided into 21 blocks isolated by motorized valves. Monitoring data of water flow and pressure are sent from telemeters to the Water Distribution Control Center. Using the data, operators remotely control the motorized valves to maintain optimal water flow and pressure (Figure 2.2). The center is run 24 hours a day by three operators and actuates about 2,000 valves a day.

FIGURE 2.2
Overview of Water Distribution Control Center



Source: Fukuoka City; modified by World Bank

The Water Distribution Control Center contributes to leakage prevention by reducing pipe pressures. In general, pipes become susceptible to damage when the pressure goes beyond 0.4 megapascal (MPa). Before the center was established, the pressure reached over 0.5 MPa during the nighttime. This increase occurred because water production facilities and reservoirs in Fukuoka City are located on hillsides,. Since the center was established, the pressure has been maintained at an average of approximately 0.4 MPa throughout the day (Fukuoka City 2019e).

The team in this case study conducted an economic evaluation of the Water Distribution Control Center and leakage reduction measures using the following assumptions:

- The Water Distribution Control Center and leakage reduction measures were combined to reduce the leakage rate from 13 percent, which was the four-year average before the establishment of the center, to 2 percent.
- Lower leakage rates led to reductions in water production and delivery costs, which are calculated based on the following equation:

  $$\textit{Cost Reduction} = \textit{Water Production \& Delivery Costs} \times (13\% - \textit{Leakage Rate})$$

  The water production and delivery costs are calculated based on the following equation:

  $$\textit{Water Production \& Delivery Costs} = \textit{Water Sales Revenue} \times (1 - \textit{Gross Margin})$$

  Note that the gross margin is assumed to be 14 percent, which is the average of the past 10 years.
- Discount rate for NPV calculation is 5%

As a result, the internal rate of return for the set of investments is 15 percent (Table 2.2) This rate indicates that Fukuoka City's investments in quality infrastructure were economically sound.

TABLE 2.2

Summary of Costs and Economic Evaluation of Key Initiatives

Summary of costs (¥ million)

		Initial investment (¥, million	Recurrent costs	
			Cumulative (¥, million)	Annual (¥, million)
Water Distribution Control Center		7,660	7,400	200
Leakage reduction program	Leakage inspections	n.a.	899	24
	Cathodic protection	n.a.	43	1
	Service pipe replacement	n.a.	857	33
	Lead service pipe replacement	n.a.	521	29

Summary of economic evaluation

Net present value	Benefit (¥, million)	32,487
	Cost (¥, million)	16,826
	B-C (¥, million)	15,661
	B/C	2.1
Internal Rate of Return (%)		15%

Note: B = Benefits; C = Costs

2.4 Complementary Interventions

2.4.1 Water Reclamation

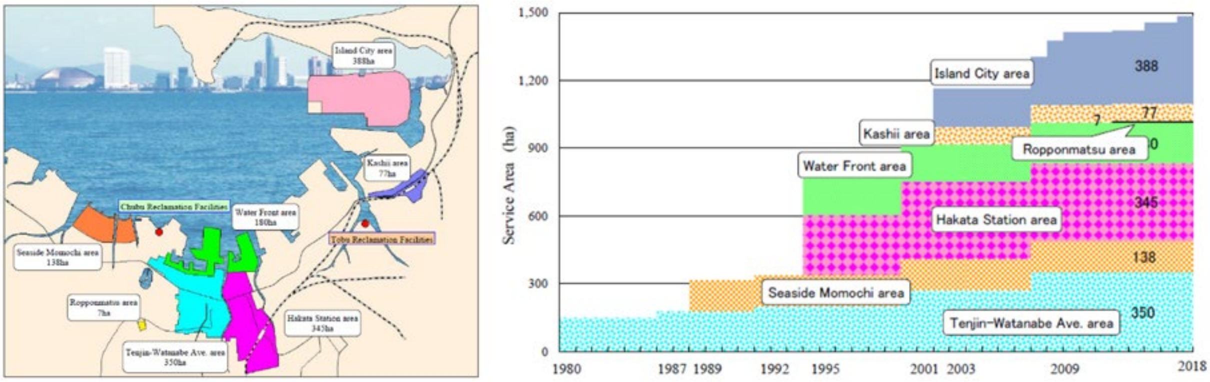
IIn 1980, Fukuoka City became the first Japanese city to supply reclaimed water. Currently, there are two reclamation facilities within the city, totalling a capacity of nearly 12,000 cubic meters (m^3) per day. The reclaimed water is used for toilets and sprinklers in more than 450 locations over nearly 1,500 hectares (ha). Through this project, Fukuoka City is partially meeting water demand with reclaimed water. The city has gradually expanded the project in accordance with a growing demand.

The water reclamation project first arose as one of the possible interventions in the water-conscious city initiative launched in 1979. Because securing additional water sources would require time owing to geographical constraints, the city considered water reclamation as a means to quickly address the growing gap between demand and supply. During the next year, the city constructed the Chubu Reclamation Facilities and began to supply reclaimed water to public buildings in the Tenjin area. At the time, the project was experimental and the service area was less than 200 ha, which is 10 percent of the current service area. Thus, the reclamation capacity was marginal.

In 1989, the city scaled up the projects to service private buildings as well. The city added the Seaside Momochi area and increased the reclamation capacity to 2,000 m^3 per day. The number of customers grew, perhaps owing to the demonstrated success. In 1996, the city significantly expanded the service area from 300 ha to nearly 900 ha. The driver for this expansion was the severe drought of 1994. That year, the water supply was restricted for 295 days. However, the supply of reclaimed water remained intact throughout the year. This experience led to incremental requests from businesses and citizens to expand the reclaimed water service area.

Since then, the city has gradually scaled up the service area covered and the reclamation capacity (Figures 2.3 and 2.4). In 2003, the city set out the Local Ordinance on Promotion of Water Saving, which required installation of miscellaneous-use water pipes for toilet facilities in buildings with large floor area (currently 3,000 square meters in areas where reclaimed water is supplied). This local ordinance further strengthened the contribution of water reclamation to the city's water-saving efforts (Fukuoka City 2018b).

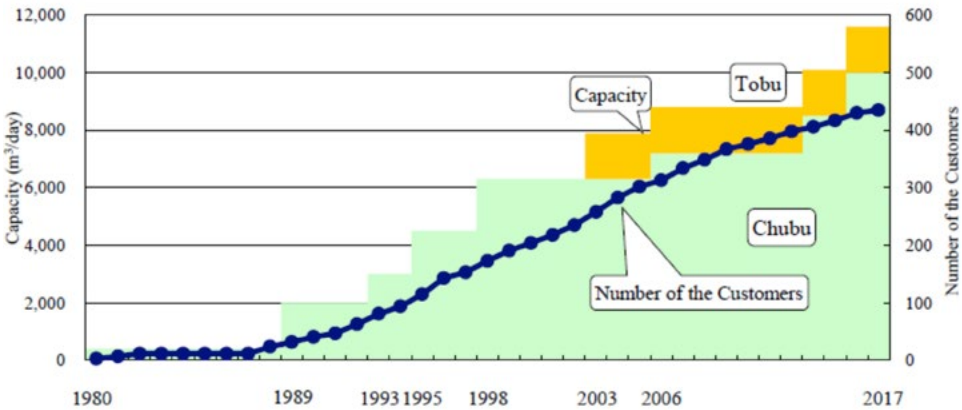
FIGURE 2.3
Reclaimed Water Service Area



Source: Fukuoka City "Reclaimed Water in Fukuoka City."

Note: ha = hectare.

FIGURE 2.4
Water Reclamation Capacity and Number of Customers



Source: Fukuoka City "Reclaimed Water in Fukuoka City"

2.4.2 Usage-based Tariffs

Fukuoka City is also adopting usage-based tariffs to incentivize water saving. Figure 2.4 provides the current monthly tariff structure in Fukuoka City. The fixed tariff is determined on the basis of the meter's diameter. The usage-based tariff is calculated differently for households and nonhouseholds.

FIGURE 2.5

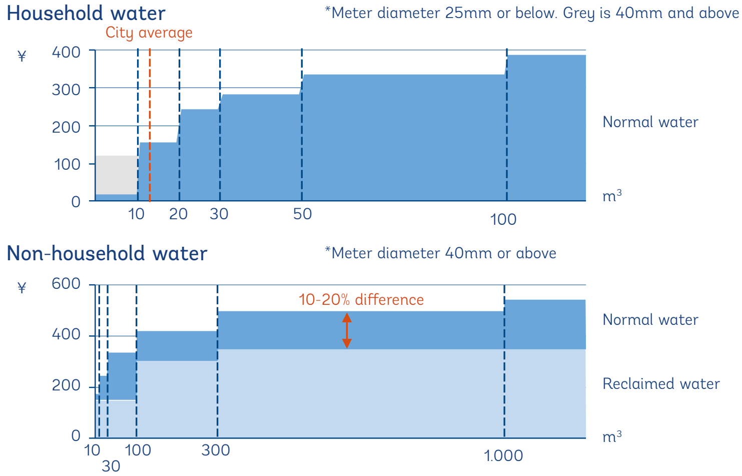
Water Tariff System in Fukuoka City

Tariff structure (monthly basis)

Fixed tariff

Meter diameter (mm)	Price (¥)
13	850
20	1,330
25	3,110
40	10,920
50	21,100
75	59,700
100	129,200
150	319,000
200	511,000
250	946,000

Usage-based tariff



Source: Fukuoka City;

For households, most have a meter diameter of 13 milllimeters (mm), so the initial tariff is 17 Japanese yen (¥) per cubic meter (m^3). Once the usage reaches 10 m^3, the tariff increases to ¥155/m^3. Because an average household in Fukuoka City consumes about 12 m^3 per month, the usage-based tariff incentivizes citizens to reduce the usage over 10 m^3. Furthermore, because there are on average 2.5 people in a household, the thresholds at 20 m^3 and 30 m^3 function as incentives for households with 3.0 or more people. For reference, the average water consumption for households in Tokyo is 8.2 m^3 for one-person households, 15.9 m^3 for two-person households, 20.7 m^3 for three-person households, 25.1 m^3 for four-person households, 27.5 m^3 for five-person households, and 33.9 m^3 for six-person households (Fukuoka City 2019f).

For nonhouseholds, the city also incentivizes the use of reclaimed water. As shown in Figure 2.5, the city provides reclaimed water at a price that is 10 to 20 percent lower than for normal water. The city determined the price considering the following two aspects:

- The price must be higher than the operating expenses to secure profitability.
- The discount from normal water must be large enough to allow customers (that is, private building owners) to recover investments for dedicated facilities and pipes.

2.4.3 Public Awareness Campaigns

Fukuoka City has continuously worked on raising public awareness since the severe drought in 1978. For example, every June 1 since 1979 has become a Water Saving Day as a reminder of hardships during the previous year. The Water Saving Day also marks the beginning of the high-use period from June to August, when public awareness campaigns are frequently held. Fukuoka City focuses particularly on youth education. For example, the city has published textbooks for elementary school and organized site visits to water-related facilities. As a result, a survey in 2015 showed that 91.5 percent of respondents in Fukuoka City are "mindful of water saving," whereas the national average is about 80 percent. Furthermore, the average consumption of household water in Fukuoka City is 199 liters per person per day. This is the lowest average among major cities in Japan (Fukuoka City 2020c).

An interesting point to add is that a unified vision of a water-conscious city may have reduced friction both within and outside the city government. At the beginning, all of the initiatives explained previously were new tasks for city officials and highly likely to require coordination with external stakeholders. Naturally, one might expect some reluctance among city officials and other involved players. However, throughout the interview process with the city officials, the authors did not hear of any such resistance. All city officials intervewed were well aware that efficient management of water resources is the primary policy objective and their daily duties are contributing to the overall goal. This organizational consensus can be regarded as an internal benefit of raising public awareness.

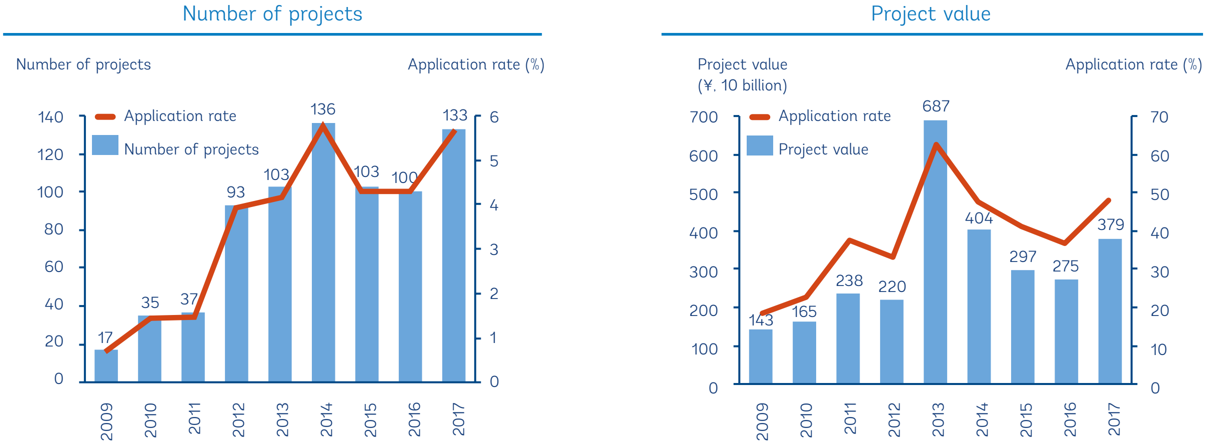
3. QII-6: Comprehensive Evaluation for Technical Quality

3.1 Introduction of Comprehensive Evaluation

As illustrated earlier, Fukuoka City pioneered life-cycle costing in Japan through its various initiatives for efficient water management. Resource constraints cultivated a prolonged commitment to the quality of investment projects within its boundaries. The introduction of comprehensive evaluation institutionalized this commitment.

The introduction of Comprehensive Evaluation began at the national level with the stipulation of the "Act on Promoting Quality Assurance in Public Works" (Quality Assurance Law), Act No. 18 on March 31, 2005. Cities across Japan struggled to integrate this evaluation method into their daily operations due to limited technical capacity and reluctance to increase the administrative burden. Fukuoka City experimentally introduced comprehensive evaluation in 2006. The system was officially introduced in 2009 and applied to only projects over 300 million Japanese yen (¥). Today, comprehensive evaluation is applied to the majority of projects in Fukuoka City, totalling about 100 projects worth ¥3 trillion every year. From 2009 to 2017, the percentage of projects that underwent comprehensive evaluation increased from 0.7 percent to 5.6 percent in number and from 18.2 percent to 47.9 percent in value (Fukuoka City 2019d; Figure 3.1)

FIGURE 3.1
Application of Comprehensive Evaluation by Number of Projects and Project Value



Source: **Fukuoka City;**

3.2 Benefits and Methods of Comprehensive Evaluation

Fukuoka City defines comprehensive evaluation as an approach used to "determine the contractor based on quality in addition to price." Here, "quality" refers not only to the quality of the building or structure to be constructed but also the efficiency and safety of construction works and environmental considerations. Furthermore, the approach also looks at the executional capabilities of the potential contractors, such as their record of success for similar projects, capabilities of key technical staff members, and a deep understanding of local environmental and social preconditions. Fukuoka City raises the following points as key benefits of introducing comprehensive evaluation:

- Improve technical quality of public works
- Encourage private companies to enhance their technical capabilities, which in turn contributes to the technological advancement of the civil engineering society
- Avoid the use of lottery in contracting[2]
- Avoid collusive pre-agreements by potential contractors

Fukuoka City uses four methods for comprehensive evaluation. Table 3.1 provides a summary of evaluation criteria and score allocation for each evaluation method:

- Type WTO (World Trade Organization): Method that adheres to the plurilateral Agreement on Government Procurement among members of the World Trade Organization and is applied to large-scale projects suitable for global procurement
- Type I: Method that considers technical proposals, executional capabilities, and staff capabilities and is applied to projects with room for technical improvements
- Type II: Method that considers operational proposals, executional capabilities, and staff capabilities and is applied to projects with little room for technical improvements
- Type III: Method that considers executional capabilities and staff capabilities and is applied to projects with little room for technical improvements

TABLE 3.1
Evaluation Criteria and Score Allocation by Evaluation Type

Evaluation criteria (correspondence to QII principles)			Evaluation type			
			Type WTO	Type I	Type II	Type III
Proposal items	Technical proposals	Technologies for · Technical specifications (QII-2) · Quality control (QII-2) · Safety measures (QII-5)	√ (4 questions)	√ (1-4 questions)	-	-
	Operational proposals	Operational approaches for · Quality control (QII-2) · Safety measures (QII-5)	-	-	√ (2 questions)	-
	Mobilization of local companies	· Sub-contracting to local companies (QII-5) · Procurement of construction material from local companies (QII-5)	√	√	√	√
Firm evaluation items	Executional capabilities	· Track record of similar projects (QII-2) · Quality control (QII-2) · Safety measures (QII-5)	√	√	√	√
	Staff capabilities	· Certifications / licenses (QII-6) · Track record of similar projects (QII-6)	√	√	√	√
	Social / local contributions	· Social contribution (QII-5) · Policy contribution (QII-6) · Disaster preparedness (QII-4) · Home location of bidder (QII-5)	-	√	√	√
	Reliability / accountability	· Past record of bid denial (QII-6)	√	√	√	√
Score allocation for "Additional Score" (from April 1, 2020)			61 - 64	20.5 - 55.5	16.5 - 21.5	10.5 - 15.5

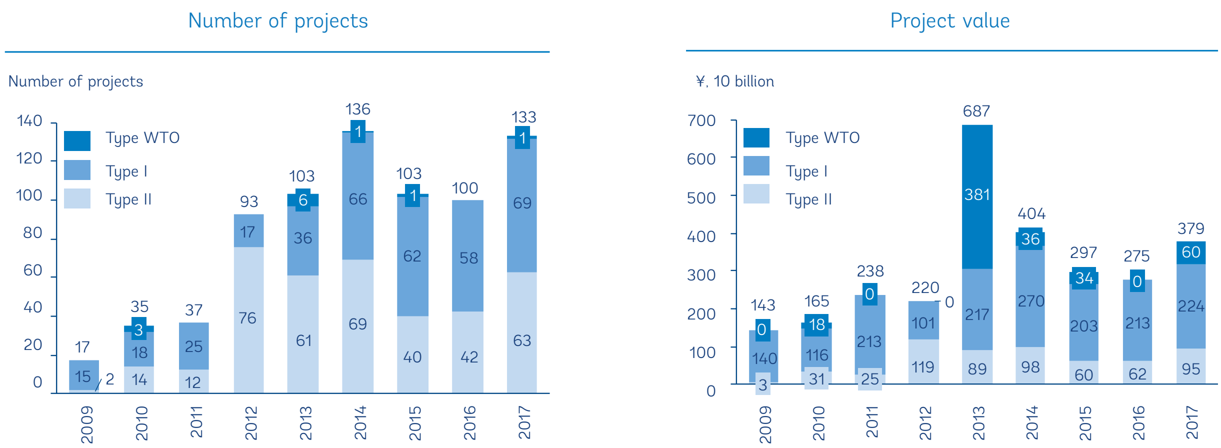
The contractor is determined based on the following equation:

$$Total\ Score = \frac{(Technical\ Score\ (= Standard\ Score + Additional\ Score))}{(Bidding\ Price)} \times \alpha$$

- Standard Score: 100 points are awarded to all firms deemed eligible to bid
- Additional Score: 0-64 points are awarded based on the technical evaluation results
- α: Adjustment parameter
    - o α = ¥1 billion for projects above ¥1 billion
    - o α = ¥100 million for projects above ¥100 million and below ¥1 billion
    - o α = ¥10 million for projects above ¥10 million and below ¥100 million

As shown in Figure 3.2, about half of the eligible projects are evaluated with Type I, and the other half are evaluated with Type II. In terms of project value, the majority of eligible projects are evaluated with Type I. For relatively small projects with little room for technical improvements, the city applies Type II and evaluates technical aspects based on operational proposals. For relatively large projects with room for technical improvements, the city applies Type I and evaluates technical aspects based on technical proposals. By doing so, Fukuoka City has reduced the additional administrative burden for the citywide operationalization of comprehensive evaluation (Fukuoka city 2019c).

FIGURE 3.2
Application of Comprehensive Evaluation by Evaluation Type



Source: Fukuoka City;
Note: WTO = World Trade Organization

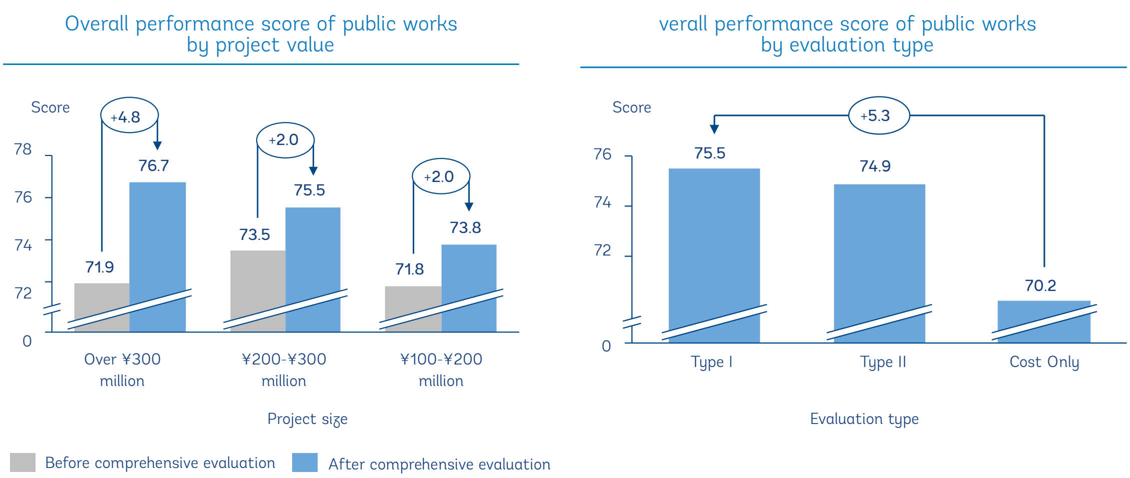
A key outcome of the introduction of comprehensive evaluation is the improvement in overall performance of public works. Fukuoka City regularly performs postevaluations on public works from the viewpoint of quality and delivery. The results indicate that the overall performance scores of public works have improved after the introduction of comprehensive evaluation compared to before its use. The improvement was particularly significant for large projects valued over ¥300 million. Furthermore, a comparison by evaluation type shows that projects assessed with the comprehensive evaluation approach performed better than projects assessed on the basis of costs only. (Figure 3.3) The evaluation criteria for these postevaluations include the following:

- Team formation
  - o Organization in general
  - o Individual technical staff members
- Executional performance
  - o Construction management
  - o Process management
  - o Safety measures
  - o External relationships
- Technical quality
  - o Conformity to technical specifications
  - o Quality
  - o Workmanship
- Project characteristics
  - o Adaptation to unique conditions
- Creativity
- Social aspects and so on
  - o Local contributions
- Legal compliance

These results provide evidence that comprehensive evaluation contributes to improving the quality of public works (Fukuoka City 2020c).

FIGURE 3.3

Impact of Comprehensive Evaluation on Overall Performance of Public Works



Source: Fukuoka City;

REFERENCES

Diamond Online. 2018. "Amazing Points about Fukuoka City! Why the City Became the 'Strongest Rural City.' July 23. https://diamond.jp/articles/-/175347. (Translated by author. Original title: 福岡市はここがすごい！「最強地方都市」になった理由.)

Fukuoka City. 2009. "Records of the Droughts in 1978 and 1994." April 1. https://www.city.fukuoka.lg.jp/mizu/somu/0053.html. (Translated by author. Original title: 昭和53年と平成6年の渇水の記録.)

Fukuoka City. 2017. "Fukuoka City Waterworks Long-term Vision 2028." April 3. https://www.city.fukuoka.lg.jp/mizu/k-kikaku/machi/vision.html. (Translated by author. Original title: 福岡市水道長期ビジョン2028.)

Fukuoka City. 2018a. Fukuoka Next. Presentation by mayor, October 25. https://www.soumu.go.jp/main_content/000582309.pdf.

Fukuoka City. 2018b. Reclaimed Water in Fukuoka City. Provided by Fukuoka City government.

Fukuoka City. 2019a. Fukuoka Facts: Over 50 Companies for 6 Consecutive Years!! Number of HQ and Companies in Growth Sectors Attracted. June 21. http://facts.city.fukuoka.lg.jp/data/new-companies-located/. (Translated by author. Original title: 6年連続50社突破!! – 本社機能・成長分野の立地企業数 –.)

Fukuoka City. 2019b. Estimated Population in the Past. December 6. https://www.city.fukuoka.lg.jp/soki/tokeichosa/shisei/toukei/jinkou/suikei.html. (Translated by author. Original title: 過去の推計人口.)

Fukuoka City. 2019c. "Fukuoka City Operational Guidelines for Comprehensive Evaluation. Provided by Fukuoka City government. (Translated by author. Original title: 福岡市総合評価方式実施ガイドライン.)

22Fukuoka City. 2019d. "Validation of "Comprehensive Evaluation" in Fukuoka City. Detailed Version." February. Provided by Fukuoka City government. (Translated by author. Original title: 福岡市における「総合評価方式」の検証【詳細版】.)

Fukuoka City. 2019e, October 21) "Water-Conscious" City Development. Efficient Water Management. Retrieved from https://www.city.fukuoka.lg.jp/mizu/mizukanri/0041.html (Translated by author. Original title: 節水型都市づくり 効率的な水運用)

Fukuoka City. 2019f. "Water Pricing Table in Fukuoka City." October 1. https://www.city.fukuoka.lg.jp/mizu/eigyo/0018_3_2.html. (Translated by author. Original title: 水道料金のしくみと計算方法・早見表.)

Fukuoka City. 2019g. Fukuoka Voice. https://www.city.fukuoka.lg.jp/data/open/cnt/3/2967/1/R1fukuokavoice.pdf?20200811160035. (Translated by author. Original title: ふくおかボイス.)

Fukuoka City. 2020a) "Overview of Fukuoka City's Economy." March. https://www.city.fukuoka.lg.jp/data/open/cnt/3/46140/1/keizainogaikyou20.3.pdf?20200318102915. (Translated by author. Original title: 福岡市経済の概況.)

Fukuoka City. 2020b. "Attractiveness of Fukuoka City." April 1. https://www.city.fukuoka.lg.jp/

keizai/k-yuchi/business/g02_index.html. (Translated by author. Original title: 福岡市の魅力.)

Fukuoka City. 2020c. "Pipe Upgrading Costs from 1965 to 2020." June 10. Provided by Fukuoka City government.

Fukuoka City. 2020d. "Water Leakage Data from 1955 to 2018." June 10. Provided by Fukuoka City government.

Fukuoka Prefecture. 2020. "Major Industrial Projects and Supporting Facilities in Fukuoka Prefecture." https://www.kigyorichi.pref.fukuoka.lg.jp/appeals/project01. (Translated by author. Original title: 福岡県の主な産業プロジェクト・産業支援施設.)

Gentosha Gold Online. 2019. "Why 'Fukuoka City' Attracts Startups from Inside and Outside Japan?" July 2. https://gentosha-go.com/articles/-/21951. (Translated by author. Original title: なぜ「福岡市」には、国内外のスタートアップが集まるのか？.)

Higashide, M. 2020. "National City Ranking of Population, Area, and Density." April 1. https://uub.jp/rnk/c_j.html. (Translated by author. Original title: 全国の市 人口・面積・人口密度ランキング.)

Ishibashi, T., and H. Shibata. 2014. "A Historical Study on Urban Strategy about Transition of Policies at Fukuoka-City in 1960's." Journal of Japan Society of Civil Engineers, Ser. D1 (Architecture of Infrastructure and Environment) 70 (1): 1–15.

Ministry of Internal Affairs and Communications. 2018. "Survey on Current Status of Municipal Finance." https://www.soumu.go.jp/iken/zaisei/h30_shichouson.html. (Translated by author. Original title: 平成30年度 市町村別決算状況調査.)

END NOTES

[1] "Class A Rivers" are rivers that are part of river systems considered to be particularly important for the maintenance of the land or national economy. These rivers are designated by the Ministry of Land, Infrastructure, Transport, and Tourism.

[2] When multiple companies bid the same price in a price-only evaluation system, the conventional solution was to determine the contractor based on the results of a lottery.