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FY2023

Report on a Study of International Cooperation in the Water Supply Sector

Synergistic Effects between Effects of Water Supply Development and Climate Change Measures through International Cooperation Activities

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Japan International Corporation of Welfare Services
JICWELS

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Abbreviations

ADB	Asian Development Bank
AFD	Agence Française de Développement
AfDB	African Development Bank
AIIB	Asian Infrastructure Investment Bank
ANDA	Administracion Nacional de Acueductos y Alcantarillados
AR4	the 4th Assessment Report
AR5	the 5th Assessment Report
AR6	the 6th Assessment Report
CDM	Clean Development Mechanism
CEB	Council of Europe Development Bank
COP12	Conference of Parties12
COVID-19	Coronavirus disease 2019
DCS	Distributed Control System
DR	Demand Response
EBRD	European Bank for Reconstruction and Development
EIB	European Investment Bank
ESCO	Energy Service Company
ESG	Environment, Social, Governance
G8	Group of Eight
GIS	Geographic Information System
FCDO	Foreign, Commonwealth and Development Office
FS	Feasibility Study
GHGs	Greenhouse Gases
GIS	Geographic Information Systems
GIZ	Deutsche Gesellschaft ｆüｒ Internationale Zusammenarbeit
ICF	International Climate Finance
ICT	Information and Communications Technology
IDB	Inter-American Development Bank
IPCC	Intergovernmental Panel on Climate Change
IsDB	Islamic Development Bank
IWA	International Water Association
JCM	Joint Crediting Mechanism
JICA	Japan International Cooperation Agency
JMP	Joint Monitoring Programme for Water Supply, Sanitation and Hygiene
JOD	Jordanian Dinars
KfW	Kreditanstalt für Wiederaufbau
MDBs	Multilateral Development Banks
MBR	Membrane Bioreactor
MIME	Ministry of Industry, Mines and Energy
MISTI	Ministry of Industry, Science, Technology and Innovation
NbS	Nature-based Solutions
NDB	New Development Bank
NIWS	Natural Infrastructure for Water Security
NRW	Non-revenue Water
NWSDB	National Water Supply and Drainage Board
ODA	Official Development Assistance
PBC	Performance-based Contracts
PES	Payments for Ecosystem Services
PPA	Power Purchase Agreement
PPIAF	Public Private Infrastructure Advisory Facility
PPP	Public Private Partnership
PRO	Pressure-retarded Osmosis

RO	Reverse Osmosis
RWF	Rwandan Francs
SABESP	Saneamento Basico do Estado de São Paulo
SCADA	Supervisory Control and Data Acquisition
SDGs	Sustainable Development Goals
UF	Ultrafiltration
UHC	Universal Health Coverage
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
UWSS	Urban Water and Sanitation Services
VPP	Virtual Power Plant
WAJ	Water Authority of Jordan
WASA	Water and Sanitation Agency
WASAC	Water and Sanitation Corporation
WASH	Water, Sanitation and Hygiene
WB	World Bank
WHO	World Health Organization

Chapter 1 Policy for the FY2023 Study of International Cooperation in the Water Supply Sector

1－1 Descriptions

(1) Background and history

In September 2015, the SDGs were unanimously adopted by the member nations of the United Nations General Assembly. The goal of the water and sanitation sectors was to secure availability and sustainable management of water and sanitation for all people. Under this goal, the UN set SDG target 6.1, which is, *by 2030, achieve universal and equitable access to safe and affordable drinking water for all*. Currently, efforts to achieve this target are underway around the world. The latest report from the JMP managed by UNICEF and the WHO, titled *Progress on household drinking water and sanitation and hygiene 2000-2020*, pointed out that billions of people around the world will still have no access to safely managed drinking water, safely managed sanitation, or basic hygiene services at home even in 2030 unless the rate of progress quadruples, and called for even more efficient and effective efforts. Climate change is predicted to have a significant impact on water facilities, water quality, and water volume. There is also a concern for the impact on water business. Effects arising presumably from climate change have already been witnessed in many parts of the world. For instance, citizens' daily living and urban activities are seriously affected when a massive flood severely damages water facilities, causing extensive water disruptions to water supplies that put limitations on core infrastructure or lifelines. To respond to such effects, some water suppliers inside and outside Japan have included their climate adaptation measures in their water safety plans. In 2017, the WHO issued the Water Safety Plan Manual for withstanding climate change, and is recommending that individual countries develop resilience against climate change in order to appropriately manage future risks and stably supply safe and high-quality water. While many countries including Japan have pledged to achieve carbon neutrality around 2050, water business uses approximately one percent of all electricity in Japan, requiring significant efforts to reconsider power sources in the water supply sector.

In June 2023, the Japanese government revised the Development Cooperation Charter to update how development cooperation should take place in light of significant changes in the situation since its formulation in 2015, and to further implement the Charter effectively and strategically. The basic policies are security of human beings, co-creation with developing nations, and the spread and enforcement of international rules for development cooperation in a new era. The priority policies are high-quality growth in the new era, including climate change, which is an urgent issue in developing nations, as well as maintenance and strengthening of free and open international order based on the rule of law. Operationally speaking, the Charter aims to evolve its approach in ways such as through co-creation with various entities to maximize development effects, and through cooperation based on offers to actively propose cooperation options, that leverage Japan's strengths to reinforce strategic characteristics through active cooperation, faster decision making, and better institutional design.

Meanwhile, the Infrastructure System Overseas Promotion Strategy 2025 approved in December 2020 stated that, *in the area of climate change measures, achieving carbon neutrality in the medium to long term requires offering of various energy shifts and decarbonization solutions that match each country's economic developmental stage and issues*. Based on this notion, the strategy highlighted the importance of co-creating, with local partners, projects to introduce high-quality Japanese infrastructure that matches the need and the financing ability of the target area, as well as the importance of involvement in human resource

development locally. As described above, there is also a need for international cooperation on climate change issues, which all humans are facing. This cannot be resolved by a single nation, so it requires joint efforts by the international community. In order to promote more effective and efficient international cooperation and contribution in the water supply sector under these circumstances, we must review past international cooperation and contributions, and plan future efforts with lessons from the past in mind.

(2) Purpose of the project

The objective of this project is to promote implementation of effective and efficient international cooperation and contribution to help the assisted nations achieve self-sustaining development of their water supply under climate change. For this purpose, experts from the business, academic, and government sectors will collect, organize, and analyze information relating to climate mitigation and adaptation strategies requiring international cooperation by the water business domain as well as priority issues that must be addressed intensively in the area of international contribution. Furthermore, they will study problem-solving approaches and assistance policies based on the needs of the assisted nations, and will share the study results with the parties concerned.

(3) Previous studies

The Ministry of Health, Labour and Welfare (MHLW) has been carrying out studies and providing recommendations with the primary focus on intangible aspects of the study theme through the Study Committee on International Cooperation in the Water Supply Sector, which was formed as part of this project. In FY2018, it conducted an on-site study in the Democratic Republic of East Timor to examine the cooperation between the water and sanitation sectors from the UHC point of view. Based on the study result, the committee concluded that both the urban and rural water supply needed improvement and recommended encouragement of local government-funded quasi-public sector entities and private sector companies in the water distribution operation, maintenance and management field to participate in future international cooperation with water suppliers and preparation of the environment for Japanese companies to enter the overseas market. The FY2019 study reported that, in the area of international cooperation by the water supply sector, support for African regions as the key regions for international collaboration was at the stage of building the foundation. It examined in great detail specific measures to be implemented to address their priority issues and how the outcomes would be monitored.

In the FY2020 study, the MHLW organized the background of efforts made in this project in the past and recommendations it had made over the previous ten years to review the positioning, direction, and outcome of this project. Also, since the ninth session of the Pacific Island Leaders Meeting was planned for 2021, the MHLW organized information on the water supply situations of the Pacific Island nations, their issues arising from the uniqueness of the Pacific Island region, and the issues for the entire region to address. It then proposed how international cooperation should take place, taking each country's situation into account. The FY2021 study focused on collaboration of water suppliers with respect to international cooperation in the water supply sector. In this study, the MHLW examined past initiatives carried out through collaboration among multiple water suppliers and investigated the effects of such collaboration and specific issues associated with it. The ministry also made efforts to promote collaboration among water suppliers and provided recommendations for building relationships with aid recipient countries, the importance of which was confirmed in this study.

In the FY2022 study covering climate change measures in the water supply sector, the MHLW examined

Japanese government policies on climate change measures, specific cases of international cooperation activities in the water supply sector to address impacts of climate change, and efforts by domestic and overseas water suppliers to achieve carbon neutrality. The ministry categorized efforts in the water supply sector into mitigation strategies, adaptation measures, and measures to train personnel in climate change, and investigated the feasibility and difficulty of deployment in developing nations, applicable conditions for implementation, key components, and other factors for each effort. The ministry also proposed a view of assessment in terms of climate change measures in the water supply sector and made recommendations on points to consider during future international cooperation activities.

(4) Policy for the present study

Building upon the findings of the previous study, which featured a foundational examination of climate change measures in the water supply sector, the present study focuses on the synergistic effects (co-benefits) between effects of water supply development and climate change measures through international cooperation activities in the water supply sector. The report features a qualitative and quantitative assessment of synergistic effects based on activity details, and considers the feasibility of simultaneously exploring sustainable water supply development and climate change measures in each project.

1) Consider synergistic effects in cases of climate change measures in international cooperation in the water business domain

- Qualitatively and quantitatively assess the synergistic effects between effects of water supply development and climate change measures for each support option through reference studies, interviews and the like, with reference to past international cooperation initiatives with the aim of supporting developing nations in addressing social changes related to climate change, and provide information to promote effective efforts and achieve sustainability in the future.
- Assess the feasibility of simultaneously exploring sustainable water supply development and climate change measures according to time span.
- Examine issues and lessons that apply to all projects.

  Specifically, the following efforts were examined:

  i) Mitigation strategies: Energy saving
  - Project for Strengthening the Business Operational Capacity of El Salvador's National Water and Sanitation Authority (Administración Nacional de Acueductos y Alcantarillados [ANDA]) (technical cooperation project)
  - Project for Improving the Energy Efficiency of Water Supply Facilities in Lahore, Pakistan (Grant Aid)
  - Project for Energy Conservation through Upgrading the Water Supply Network in the Hashemite Kingdom of Jordan (Grant Aid)

  ii) Mitigation and adaptation strategies: Improvement of water distribution (shift from pressurized pumping to gravity flow, water leakage reduction through water pressure correction)
  - Secondary Project for Improving the Water Supply Facilities in the Zarqa Area of the Hashemite Kingdom of Jordan (Grant Aid)
  - Master Plan Project of Waterworks Improvement and Maintenance in Kigali, Rwanda (technical cooperation through development plan study)

  iii) Mitigation and adaptation strategies: Water leakage reduction

- Project for Strengthening the Capability to Reduce Non-Revenue Water in Colombo, Sri Lanka (technical cooperation project)
- Non-Revenue Water Management Project in Brazil (technical cooperation project)
- Project for Repairing and Expanding Water Service Pipes in Provincial Capitals in Cambodia (Grant Aid)

2) Application of efforts by domestic water suppliers to achieve carbon neutrality to support developing nations

Cases that can be used to support developing nations are extracted from the efforts of domestic water suppliers to achieve carbon neutrality, which are also assessed.

We extract cases with the potential to support developing nations from the efforts of domestic water suppliers to achieve carbon neutrality examined in the last fiscal year. We then organize overviews of these efforts, expected effects, and matters related to adapting them for developing nations, such as issues and required devices. Finally, we compile these as insights that help to support developing nations. We leverage the opinions of committee members when extracting cases and collecting information on issues and required devices related to adaptation.

3) Insights on innovations leveraging products and technologies from Japanese companies, and site visits

We compile and share insights on innovations that can be showcased through site visits when people in the water supply business visit Japan, focusing particularly on efforts that leverage products and technologies from Japanese companies.

We extract information on innovations in the water supply sector and companies with innovative technologies and products from past reports, information releases about of water suppliers and other related parties, companies' trade show information, and other sources. We also make inquiries to extracted companies about their site visits and organize and compile notes on implementation, etc.

4) Synergistic effects between climate change measures, etc, and cases of international cooperation efforts with other countries or development-related organizations in the water supply sector.

We obtain information on cases of international cooperation efforts with other countries or development-related organizations to address climate change impacts and social concerns in the water supply sector, and synergistic effects between these efforts and action against climate change, etc. on the Internet or by other means, and organize particularly characteristic information.

5) Discussion on strategies for making future international cooperation more effective and efficient

We compile the direction and specific strategies of future international cooperation and contribution that take climate change measures into account, considering strategies for parties involved in international cooperation in the water supply sector for wide and long-term use in light of committee considerations and deliberations to date.

1－2 Study Task Force

(1) Committee structure

The period of this study was one year. The Study Evaluation Committee was formed, and the study results were reported at committee meetings, three of which were held. The committee members for the FY2023

study are listed below.

(Honorifics omitted; committee members' names are in Japanese alphabetical order)

[Committee members]

Taikan Oki	Professor, Department of Civil Engineering, School of Engineering, University of Tokyo
○ Hidetoshi Kitawaki	Professor, Faculty of Global and Regional Studies, Toyo University
Yoko Saito	Deputy Director for the International Affairs Team, Planning and Coordination Section, General Affairs Division, Bureau of Waterworks, Tokyo Metropolitan Government
Keisuke Sonoda	Assistant Manager, Management and Planning Division, Operations Department, Saitama City Waterworks Bureau
Kenichi Matsumoto	Manager, Shijonawate Water Supply Center, Osaka Water Supply Authority
Shigeyuki Matsumoto	Deputy Director General, and Group Director for Water Resources, Global Environment Department, JICA
Takayuki Miura	Senior Researcher, Department of Environmental Health, National Institute of Public Health
Tatsuo Morimoto	Senior Advisor, Federation of Japan Water Industries, Inc.
Kunio Yamashita	Sales Group Leader, Overseas Business Department, Environmental System Headquarters, Yokogawa Solution Service Corporation
Noriko Yokoyama	International Director, Training and International Department, Japan Water Works Association (JWWA)

(○: Chairperson)

[Administrative office]

Tetsuya Itani	Director, Office of Global Health Cooperation, International Affairs Division, Minister's Secretariat, MHLW
Moeko Yoshitomi	Deputy Director, Office of Global Health Cooperation, International Affairs Division, Minister's Secretariat, and Deputy Director, Water Supply Division, Public Health Bureau, MHLW
Takeo Yamaguchi	Technical Advisor, JICWELS
Yuichi Hashimoto	Technical Advisor, JICWELS
Naofumi Owada	Deputy Manager, International Cooperation and Training Department, JICWELS
Mai Isohata	International Cooperation Section, International Cooperation and Training Department, JICWELS
Sachiko Ochiai	International Cooperation Section, International Cooperation and Training Department, JICWELS
Urara Imajo	Water Partners Jp Co., Ltd.
Mikiko Fujiwara	Water Partners Jp Co., Ltd.

[Topic provider]

Koichi Matsubara	Deputy General Manager, Overseas Water Supply Department, Overseas

	Business Unit, Consulting Headquarters, Nihon Suido Consultants Co., Ltd.

[Observers]

Yasufumi Imoto	Deputy General Manager, Water Supply Division, Health and Environmental Sanitary Bureau, MHLW
Hideo Takenaka	Deputy General Manager, Water Supply Division, Health and Environmental Sanitary Bureau, MHLW
Nana Aoki	Senior Chief, Water Supply Division, Health and Environmental Sanitary Bureau, MHLW
Toshiki Miyagawa	Consulting Room, Water Supply Division, Health and Environmental Sanitary Bureau, MHLW

(2) Committee meeting schedule

Three committee meetings have been scheduled for FY2023. The (scheduled) meeting dates are listed below. All three meetings take place online.

[Meetings]

1st meeting: June 26, 2023
2nd meeting: November 6, 2023
3rd meeting: January 15, 2024

[Domestic study]

From May 2023 to January 2024

[On-site study]

September 9 to 18, 2023 (Kigali, Republic of Rwanda)

Chapter 2 Considering Synergistic Effects of Climate Change Measures in International Cooperation in the Water Supply Sector

2－1 Climate Change and Water

(1) Climate change and water

The relationship between climate change and water has gained global recognition, leading to various international and domestic movements. The main movements are outlined below.

1) Description of water supply in the AR6

The AR6 focuses on energy, ecosystems, infrastructure, and transformation and system transition in industry and society. The report also emphasizes the need for processes to implement mitigation and adaptation together for climate-resilient development.

According to the report, anthropogenic climate change has already caused a wide range of negative effects and associated losses and damage to nature and human beings, with an increase in the frequency and severity of extreme phenomena. Examples of climate change risks related to water supply include increases in heat waves, floods, heavy rains, and droughts, rises in sea level, the loss of biodiversity in land, freshwater and marine ecosystems, and changes in water availability. The report also points out that the scale, speed, and related risks of climate change depend on short-term mitigation and adaptation actions and that the negative effects, loss, and damage spread in proportion to global warming.

Regarding climate change measures, the report shows that although the planning and implementation of adaptations have made progress, the distribution of generated benefits is uneven with adaptation gaps. Furthermore, it indicates that GHG emissions have not reached the level required to achieve the future temperature change goal though mitigation strategies, and that policies have also advanced. Climate change measures related to water supply include consideration of the impacts and risks of climate change during design and planning, improvement of energy saving and energy efficiency, electrification and low-carbon resources, reduction or change in material consumption, water infrastructure improvement, and reduction in exposure to floods.

Acceleration of equitable actions for mitigation and adaptation are critical for sustainable development. These actions provide more synergistic effects than tradeoffs with SDGs. Climate-resilient development is realized through equitable, inclusive, and fair transformation and system transition processes. This requires international cooperation as well as collaboration and partnership among various entities, which leads to the need for comprehensive efforts that enable them such as governance, systems, finance, and information.

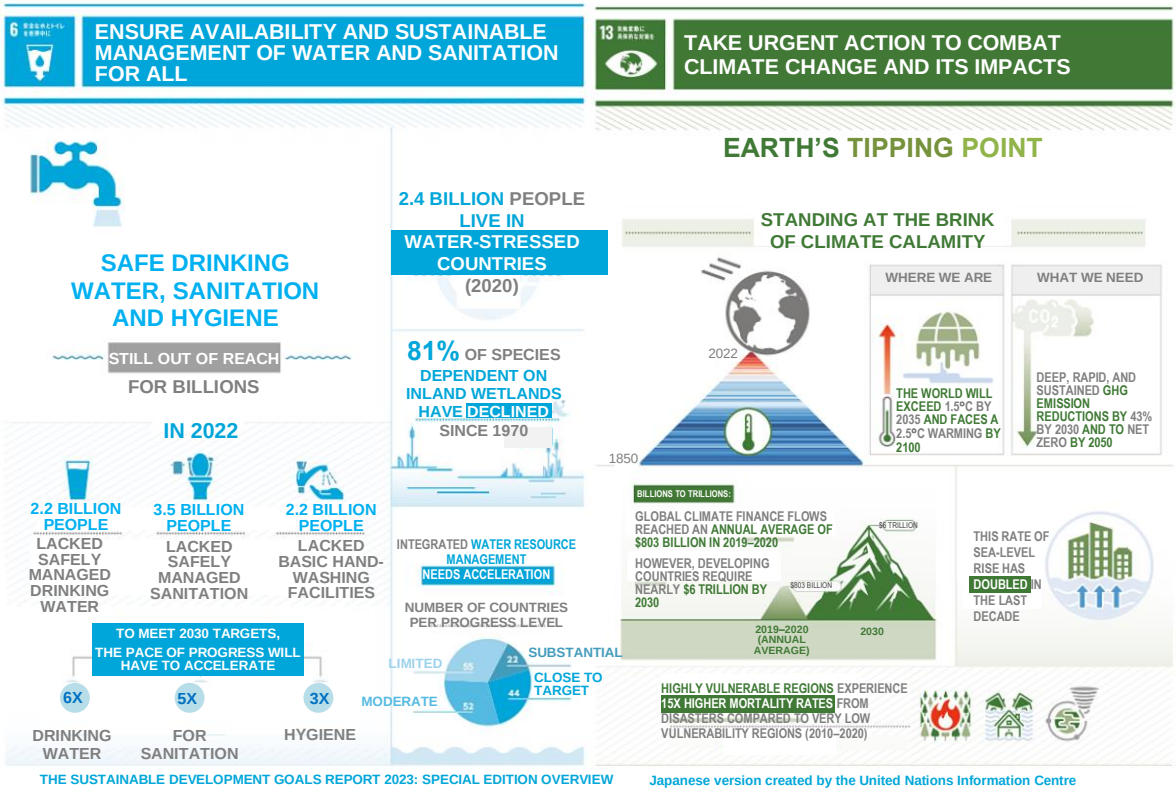
2) Outline of the Sustainable Development Goals Report 2023

According to the Sustainable Development Goals Report 2023: Special Edition announced in July 2023, half of about 140 assessable targets are experiencing medium to severe deviations from desirable courses. The report warns that while global issues such as the impacts of the climate crisis and the COVID-19 pandemic have hindered progress toward achieving the goals, their most severe consequences have affected the world’s poorest and most vulnerable populations.

Regarding SDG 6, 2.2 billion people still have no access to safely managed drinking water as of 2022, even though the global population that can access safely managed drinking water services increased by 687 million (from 69% to 73% of the world’s population) from 2015 to 2022. The access has been improved in rural regions but it has declined in urban areas, and the current speed of progress must be accelerated six

times to achieve universal coverage by 2030. In addition, water stress and water shortages are still of concern in many regions; in 2020, 2.4 billion people were living in countries with water stress even though water usage efficiency has improved. This issue has been aggravated by conflicts and climate change.

As for SDG 13, the pace and scale of current planning of climate change measures is far from sufficient to effectively combat climate change, and extreme weather events with increasing frequency and severity have already affected every region on Earth. Temperature rises further escalate these dangers and present serious risks. Global warming by around 2.5°C is expected by the end of this century under the present circumstances even though GHG emissions need to be almost halved by 2030 to achieve the 1.5°C target. It is essential to reduce GHG emissions significantly, rapidly, and sustainably in every domain. Also necessary is to show a clear path toward achieving net-zero emissions through urgent and innovative actions, while encompassing the entire economy and boosting motivation for transitioning to climate change-resilient development.



(Source: Overview of the Sustainable Development Goals Report 2023: Special Edition, United Nations Information Centre)

3) United Nations Water Conference (March 2023)

About two billion people worldwide still lack access to safely managed drinking water. Many water resources are contaminated, and climate change has caused droughts and floods. In response to these situations, the United Nations Water Conference[1], a UN conference dedicated to water, took place in March 2023 at the United Nations Headquarters in New York for the first time in 46 years. The aim was to raise awareness about the global water crisis and determine cooperative actions to achieve internationally agreed-upon water-related goals and targets, including SDGs. The Water Action Agenda resulting from the conference reflects the international community's determination to address water-related issues through a

more cooperative and result-driven approach, and includes over 700 commitments. Governments, corporations, and civic communities promised several billion dollars to promote the Water Action Agenda. For example, the United States committed up to 49 billion dollars in investments to support resilient water and sanitary infrastructure and services to combat climate change. Switzerland submitted five commitments to contribute to UN efforts, including the Water Convention and cross-border cooperation. The ADB pledged to invest 11 billion dollars in the Asia-Pacific region's water sector and 100 billion dollars in the global water sector by 2030. In the private sector, five global corporations announced contributions totaling around 140 million dollars, jointly with the US government, to the Water Access Fund. This would provide water and sanitation access to five million people.[2]

Of five thematic panel discussions at the United Nations Water Conference 2023, the Japanese government, as co-chair of thematic panel discussion 3, made recommendations to make the global water domain resilient. The panel discussed topics such as water-related climate change and resilience enhancement, drawing upon Japan's experience in water disaster control. The government also announced contributions through initiatives such as promoting the establishment of high-quality infrastructure and the Kumamoto Water Initiatives, which includes financial aid amounting to approximately 500 billion yen over the next five years to solve global water problems.[3]

4) Power consumption in the water supply sector

According to water supply statistics, power consumption by the water business in Japan was 7.4 billion kWh in FY2020.[4] This accounted for about 0.8% of the power consumption across Japan, which was 907.4 billion kWh in FY2020, decreasing by 2.1% from the previous fiscal year.[5] Meanwhile, a total of 38,523,156 kWh of renewable energy was generated in the water supply domain with an increase in implementing entities. The breakdown comprises hydroelectric power (66.9%), solar power (31.8%), and wind power (1.3%).

In FY2020, the water business emitted 3.4778 million t-CO_2 in relation to electricity (total of prefectures using the default CO_2 emission factor of 0.470 kg-CO_2/kWh). Although the number decreased by 222,400 t-CO_2 from 3.7002 million t-CO_2 in FY2018, this reduction can be attributable to improvement of the CO_2 emission factor because power consumption remained almost the same between FY2018 and FY2020.

5) Description of the water supply sector and CO_2 reduction goal in the water supply sector in the report under the UNFCCC

Japan's Fifth Biennial Report under the UNFCCC (December 2022) lists the promotion of energy saving through the introduction of energy-saving and high-efficiency equipment, as well as energy-saving facilities such as inverter-controlled pumps and wide-area expansion, consolidation, and reallocation of energy-saving facilities, the introduction of renewable energy generation facilities including small-scale hydroelectric and solar power generation, as mitigation strategies in the water business. The report also mentions a long-term effort to explore the possibility of water facilities contributing to power supply-demand adjustments.[6]

The report sets a goal of a reduction amounting to 216,000 t-CO_2 (fall of about 5% compared to FY2013) by FY2030 in the water supply sector to achieve carbon neutrality in 2050. Even though the result has improved since FY2017 as of FY2020, the amount of emission reduction compared to FY2013 increased by 2,000 t-CO_2, making this goal difficult to achieve unless the current situation changes.

The government is working on this situation through efforts such as the introduction of energy-saving and renewable energy generation facilities by water suppliers, financial support for such introduction (special accounts for energy), the promotion of energy saving through wide-area expansion, consolidation, and reallocation of water facilities, and exploration of the possibility of water facilities' ability to adjust the water supply to help modulate electricity supply and demand. The government is promoting further decarbonization, for example, by organizing seminars on decarbonization in the water supply sector (such as subsidies for the industry) for water suppliers and other related parties.[7]

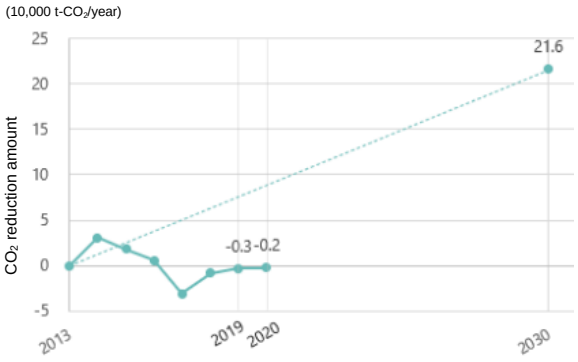


Figure: Transition of CO_2 Reduction Amount and FY2030 Goal in the Water Business

6) Examples of climate risks and adaptation measures in the water supply sector shown in JICA Climate-FIT

JICA has developed a proprietary support tool for climate change measures called JICA Climate-FIT (mitigation and adaptation strategies). JICA Climate-FIT (adaptation strategies) provides guidance on assessing climate risks and considers adaptation measures at the planning and preparation stages of development projects. It also provides examples of climate hazards, exposure, vulnerabilities, climate risks, and adaptation measures in the water business.[8] Tables 1 and 2 show examples of climate risks and adaptation measures from them.

Table 1 Examples of Climate Risks in the Water Business Shown by JICA Climate-FIT (Adaptation Measures)

Subject		Examples of climate risks
Hard infrastructure	Expenses and spending related to water storage, water intake, water purification facilities, and water distribution facilities, etc.	Damage to facilities
		Degradation of functionality
		Intrusion of rainwater, sewage, etc.
		Change in the annual operation, maintenance and management costs per unit of drinking water facilities
Soft infrastructure	Organizations and people involved in projects	Deterioration of adequate water supply capacity
		Suspension of adequate facility and equipment maintenance and management
		Degradation of maintenance and management capabilities
Surrounding environment	Access to water resources	Limitations on or lack of access to safe water
		Change in the water supply-demand balance
		Change in the number of months without a water shortage in a year, and lowering or improvement of reliability resulting from the change
		Change in the number of days with 12 hours or more of suspended water supply (cuts in water supply) in a year, and improvement or lowering of reliability resulting from the change
	Sanitation	Increase in the incidence of waterborne infectious diseases
		Fluctuations in the mortality rate of children under 5 years old (deaths per 1,000 live births) corresponding to changes in sanitary water supply

Subject		Examples of climate risks
	Sources	Soil erosion in catchments
	Water resources	Deterioration of water quality (changes in turbidity, BOC, phosphorus, nitrogen, etc.)
		Limitation or suspension of water intake due to significant intrusion of soil and sand
		Change in groundwater level or water quality
		Decrease in glaciers
		Increase or decrease in annual available water resources

Source) Table 34 Examples of Climate Risks in Water Resources Domain (Water Supply) Projects in 5.2.2, "Water resources domain" in JICA Climate-FIT (adaptation measures)

Table 2 Examples of Adaptation Measures in the Water Business Shown in JICA Climate-FIT (Adaptation Measures)

Category		Examples of adaptation measures
Hard infrastructure	Water storage, water intake, water purification facilities, and water distribution facilities, etc.	Securing of backup power supplies for water treatment facilities and pump equipment
		Relocation to or installation in high places
		Facilities design with multiple water intake options, assuming frequent rain (e.g., increasing the capacity of catchments, bearing high turbidity of taken water if frequent heavy rain is expected)
		Selection of locations for installing water service pipes outside flood-prone areas
		Installation of highly watertight doors or relocation of critical machinery and facilities to elevated areas
		Maintenance of aged facilities, etc.
		Upgrades (dam bank raising)
		Capacity strengthening
Soft infrastructure	Organizations and people involved in projects	Inclusion of climate change risks in investment design plans
		Business continuity planning (BCP)
		Creation of a water-use management strategy for an entire catchment
		Creation of water intake plans that take into account changes in precipitation and river flow rates
		Collection of climate data and the severity and frequency of disasters and climate hazards
		Strengthening of facility and equipment maintenance
		Strengthening of personnel maintenance and management capabilities
		Budget for maintenance and management and human development
		(1) Change of land-use plans (not installing water purification plants and water distribution and water supply pipes) and (2) revision of infrastructure design standards in light of future aggravation of climate hazards
	Sources	Forest protection around sources
		Improvement of the water source monitoring capacity
		Retention of vegetation in upper river catchments
		Diversification of water supply sources/resources

Source) Table 35 Examples of Adaptation Measures in Water Resources Domain (Water Supply) Projects in 5.2.2, "Water resources domain" in JICA Climate-FIT (adaptation measures)

(2) Concept of synergistic effects with climate change measures in international cooperation

How the concept of synergistic effects has gained attention in international cooperation and their current definition, the development of the co-benefit approach in Japan, and efforts by the Ministry of Environment (MOE) and JICA are shown below.

The co-benefit approach is a concept particularly important in developing nations. This approach intends to promote efforts that contribute to the sustainable development of developing nations while climate change measures are implemented. The aim of this approach is to shape climate change measures suitable for economic and social needs. This is to promote and put proactive and highly feasible responses to climate change into action, which must occur on a global scale, and simultaneously solve domestic and regional issues in developing nations, where realizing economic and social development and mitigating environmental problems are high priorities.

Approaches and efforts focused on co-benefits have been considered as possible incentives for developing nations to proactively work on climate change measures since COP12 (Nairobi Conference) in 2006, where developing nations issues were highlighted. The AR4 Summary for Policymakers (November 2007) points out that *it is possible to create synergistic effects with other aspects of sustainable development and implement climate action options to avoid conflict in some sections*.[9] Policies designed to consolidate multiple goals to increase co-benefits and reduce negative secondary effects would attract more attention in subsequent plans and strategies related to adaptation and mitigation created by national governments and the like. The AR5 Synthesis Report, Summary for Policymakers (April 2014) uses co-benefits as secondary positive effects of mitigation strategies other than the effects of reducing and absorbing GHG emissions, and points out that there are many opportunities to link the explorations of mitigation, adaptation, and other social goals through integrated action.[10] The overview of the AR6 Synthesis Report Summary for Policymakers (March 2023) also shows that accelerated and equitable actions in mitigating and adapting to impacts of climate change are essential to sustainable development, that mitigation and adaptation actions have more synergistic effects than tradeoffs with SDGs, and that options to reduce high-emission consumption have co-benefits with social wellbeing.[11]

The Japanese government emphasized the importance of the co-benefit approach in Cool Earth 50 announced by (then) Prime Minister Abe in May 2007. The government has taken the initiative in promoting this approach at subsequent important conferences, dramatically raising interest in it within and outside Japan. For instance, the approach was discussed at G8 Environment Minister Conferences and other international conferences and mentioned in the Hokkaido-Toyako Summit Leaders' Declaration (July 8, 2008).

The MOE considered strategies and other matters to promote development policies, antipollution measures, and anti-global warming measures in an integrated way in developing nations, and in October 2008 completed "Toward the Promotion of Co-Benefit-Type Anti-Global Warming Measures and CDM to Implement Environmental Measures in Developing Countries." The co-benefit-type anti-global warming measures and CDM in the domain of environmental measures refer to measures and projects to improve the environment (reduce contaminants) as one of the development needs in developing nations while reducing GHGs at the same time. According to the ministry, anti-global warming measures can be effectively promoted with high incentives in developing nations by encouraging the implementation of co-benefit-type measures and projects where environmental action can be taken while reducing GHGs.[12] Current efforts to promote co-benefit-type projects include co-benefit CDM model projects, bilateral

cooperation using the co-benefit approach, building and activity support of the Asia Co-benefits Partnership, which is a multinational framework, support study activities to expand projects with co-benefit effects, and mainstream the co-benefit approach in environment policies and the like.[13]

JICA also emphasizes the concept of co-benefits. JICA considers the co-benefit approach as something that contributes to climate change measures (climate benefits) while solving development problems (delivering development benefits). To promote the co-benefit-type approach, this ODA-implementing agency is exploring and studying ideal cooperation beneficial to both sustainable development and climate change measures in developing nations. For example, the agency released "Co-Benefit-Type Climate Change Measures and JICA Cooperation" a report analyzing cases of approaching climate change mitigation measures starting with development (June 2008).[14] In 16, "Climate change" in the JICA Global Agenda (issue-specific project strategy) created in 2021 to promote climate change measures in development projects in developing nations, JICA set the promotion of implementing the Paris Treaty and co-benefit-type climate change measures as the pillars for advancing climate change measures and set specific numerical goals.[15] JICA's fifth medium-term plan (2022-2026) started in April 2022, and the FY2023 plan, also define climate change measures as a priority issue and clearly state that the agency will actively promote them in the climate change domain under *building a sustainable and resilient international community by working on global issues*, which is one of the priority issues of Japanese development cooperation.[16, 17] They have also promoted *mainstream climate change measures*, incorporating mitigation and adaptation perspectives into all development projects, and integrated climate change considerations and measures into project plans at the planning stage by applying their support tool for climate change measures (JICA Climate-FIT) and other means.

Regarding other development-related organizations, the WB, for example, is actively mainstreaming considerations for climate change in their investments and operations. Specifically, the bank provides Climate Co-Benefits, a loan dedicated to adaptation to and mitigation of climate change, and has set a target percentage for loans with climate co-benefits in their total lending.[18]

2－2 Study Policy

Building upon the findings of the previous study, which listed specific implementation measures and addressed the status of international cooperation efforts in categories, such as mitigation strategies, adaptation strategies, and measures to train personnel in climate change who support these measures regarding climate change measures in the water supply sector, the following three points were studied and examined in this survey. The focus was on synergistic effects between effects of water supply development and climate change measures through international cooperation activities in the water supply sector.

- Qualitatively and quantitatively assess the synergistic effects between effects of water supply development and climate change measures for each support option through reference studies, interviews, and the like, with reference to past international cooperation efforts aimed at supporting developing nations address social changes related to climate change, and provide information to promote effective efforts and achieve sustainability in the future.
- Assess the feasibility of simultaneously exploring sustainable water supply development and climate change measures in accordance with the time span.
- Examine issues and lessons that apply to all projects.

Table 3-1 lists specific target examples of international cooperation leveraging Japanese ODA are listed in, and Table 3-2 shows those of projects implemented by foreign international cooperation or international development organizations. Among these examples, this chapter examines eight projects implemented by Japan, and Chapter 5 outlines projects by foreign international cooperation or international development organizations. The breakdown of the eight projects comprises three projects to improve the efficiency of electricity use in the water business to save energy, two projects to improve water distribution by shifting from pressurized pumping to gravity flow and reducing water leakage with water pressure correction, and three projects to help reduce water leakage.

The objective of international cooperation in the water supply sector is to sustainably manage water business in target countries and to provide a stable supply of safe water. Increasing the efficiency of electricity use and saving energy improves the state of management by reducing electricity costs in the water business. These are positioned as mitigation strategies that lead to reducing GHG emissions in terms of combating climate change. Furthermore, reducing water leakage by improving water distribution systems and the resultant fall in the rate of non-revenue water improve management by increasing fee revenue and reducing maintenance and management costs in the water business. These serve as both mitigation and adaptation strategies to reduce GHG emissions and improve the sustainability of water sources through the effective use of water resources as climate change measures. Consequently, these actions lead to a sustainable water supply. Table 4 shows the study policy determined based on discussions at committee meetings to ensure that study methodology and summary align with this approach.

Table 3-1 Target Examples (International Cooperation Leveraging Japanese ODA)

Category		No.	Project title	City and region	Aid type
Mitigation strategies	Energy saving	1)	Project for Strengthening the Business Operational Capacity of El Salvador's National Water and Sanitation Authority	Metropolitan area, western region, and central region	Technical cooperation project
		2)	Project for Improving the Energy Efficiency of Water Supply Facilities in Lahore, Pakistan	Lahore in Punjab	Grant Aid
		3)	Project for Energy Conservation through Upgrading the Water Supply Network in the Hashemite Kingdom of Jordan*	Zarqa	Grant Aid
Mitigation and adaptation strategies	Improvement of water distribution (shift from pressurized pumping to gravity flow, water leakage reduction through water pressure correction)	4)	Secondary Project for Improving the Water Supply Facilities in the Zarqa Area of the Hashemite Kingdom of Jordan	Northern area of Zarqa, cities of Hashimieh and Sukhna in Zarqa	Grant Aid
		5)	Master Plan Project of Waterworks Improvement and Maintenance in Kigali, Rwanda	Kigali and seven sectors around it	Technical cooperation through development plan study
	Water leakage reduction	6)	Project for Strengthening the Capability to Reduce Non-Revenue Water in Colombo, Sri Lanka	Colombo	Technical cooperation project
		7)	Non-Revenue Water Management Project in Brazil	Sao Paulo State	Technical cooperation project
		8)	Project for Repairing and Expanding Water Service Pipes in Provincial Capitals in Cambodia	Provincial capitals of Pursat, Preah Sihanouk, and Battambang	Grant Aid

*Projects subject to the FY2022 international cooperation consideration project study in the water supply sector

Table 3-2 Target Examples (Projects Implemented by Foreign International Cooperation or International Development Organizations)

Category	Implementing organization	Project	Country and region
Mitigation strategies	GIZ	Energy saving in the water business	Jordan
	USAID	National guidelines on the solar power generation/water supply system in Ethiopia	Ethiopia
Mitigation and adaptation strategies	WB and IWA	Application of performance-based contracts (PBC) to private-public collaboration for non-revenue water management	Belize and Jordan
	ADB	Application of performance-based contracts (PBC) to private-public collaboration for non-revenue water management	Karnataka, India
	AFD	Innovation combining water treatment and green energy in the West Bank	West Bank
Adaptation strategies	USAID	Investment promotion through payments for ecosystem services (PES) in Peru	Peru
	USAID	Water demand management among users in Lebanon	Lebanon
	AFD	Natural nature recovery in the Qixian Wetlands, China	China
	AFD	Protection of water resources in Pout, Senegal	Pout, Senegal
	KfW	Water project for the Global South (drinking water production from treated sewage)	Namibia
	ADB	Water production for industrial water use	Maharashtra, India, etc.

Table 4 Study Policy

Item	Matters to examine and consider
Qualitative and quantitative assessments on synergistic effects of water supply development and climate change measures, using support options	(1) Examine information on each project. • Basic information • Issues (water supply issues, climate change issues, and social issues) • Goals • Actions to implement • Qualitative and quantitative data on effects (effects of water supply development, climate change measures, and social issues) (2) Examine the effects of the projects by item, and consider synergistic effects.
Assessment of the feasibility of simultaneously exploring sustainable water supply development and climate change measures according to time span	Regarding sustainable water supply development and climate change measures: (1) Examine short-term issues, improvement measures, resulting benefits, and disadvantages. (2) Examine long-term issues, improvement measures, resulting benefits, and disadvantages. (3) Discuss the feasibility of solving the issues.
Organization of issues and lessons that apply to all projects	(1) Extract the issues and lessons from individual projects. (2) Examine common items.

2－3 Overview and Issues of Each Project

An overview of each project is provided in the data section. Table 5 lists data on each project as well as water supply issues, climate change issues, and other social issues in target projects and regions extracted

from survey data on the climate change measures taken in each target country. Table 6 shows climate risks associated with the water business in each project extracted from Table 5 and Tables 1 to 8 in the data section and examined using Table 1.

Table 5 Issues in the Target Business and Region of Each Project

Country	Water supply issues	Climate change issues	Other social issues
1) El Salvador	• High non-revenue water rate (estimated to be about 50%) • Electricity use accounts for 35% of spending. • Relatively high maintenance and management costs mainly caused by high electricity rates and low pricing put pressure on management. • Intermittent water supply in some regions due to the lack of capacity at water supply facilities and lack of water resources • Other regions without sufficient water supply	• Inefficient power consumption • High power consumption • Geographical conditions that lead to susceptibility to the impact of nature disasters such as torrential rain	• Sewage effluent, 97% of which is untreated before discharge to river
2) Pakistan	• Aging of water facilities that have deteriorated pumping capacity, leading to a fall in the amount of supplied water • Power costs, which have reached about 45% of the operating cost due to a rise in electricity prices and soaring generator fuel prices • Intermittent water supply for about 14 hours a day due to causes such as planned outages resulting from serious electricity shortages • Chlorine injectors less likely to function in deep wells, causing waterborne diseases • A rise in the arsenic level of groundwater	• Deterioration of the energy efficiency related to water pumping, which increases energy consumption • Impacts of flash flooding due to melting glaciers or other causes, heavy rains and floods caused by the monsoon, cyclones, droughts, heat waves, and other phenomena arising from climate change	• A drop in the groundwater level due to excessive water pumping in regions that have privately owned wells. This is expected to further worsen due to an increase in the urban population. • Saline groundwater approximately 42 km southeast of Lahore
3) Jordan	• Constant water resource shortage due to its location in the desert region (The water resource reserves per capita was 145 m^3/year in 2008.) • An increase in water demand due to increases in population and refugee acceptance • Reduced water supply and distribution capacity due to aging pumps and frequent failures resulting from inadequate maintenance and management (The daily water supply is about 140 L/day.) • Increasing electricity cost ratio, already as high as 60% to 70%, due to geological conditions that necessitate the use of many pumps	• As almost all electricity depends on thermal power generation, inefficient pumps increases GHG emissions as well as power consumption. • Rising electricity prices • Securing of drinking water is expected to be more difficult because water availability is said to lower due to climate change in the Middle East.	• The population inflow from neighboring countries (including refugees, evacuees, and unemployed migrant workers) has also continued to increase, leading to a high unemployment rate and poverty rate.

Country	Water supply issues	Climate change issues	Other social issues
4) Jordan	Same as 3) • Delays in planned measures to control water leakage, negative pressure in pipes due to intermittent watering, and insufficient chlorination • Despite a high penetration rate of 98%, water supply is limited to only 12 to 72 hours a week in some regions due to water supply constraints.	Same as 3) • Power consumption is high due to heavy use of water pumps.	Same as 3) • A better life is desired, but as access to water supply takes effort and time and people must purchase expensive water from private water dealers. • The target region includes refugee camps. A better living environment and stable livelihood are desired.
5) Rwanda	• The capacity of facilities is insufficient to handle an increase in water demand due to a population surge. • Current water sources may stop providing sufficient amounts of water in the near future. • Because the elevation varies within the city, there is pipe damage, water leakage, and energy loss due to insufficient water pressure management. • Intermittent water supply, low water pressure, and a high water leakage rate • Reduced water purification capacity due to high turbidity of the water source • High electricity costs, accounting for about 50% of production costs	• Water supply system that consumes an enormous amount of energy • Increase in heavy rain disasters such as submersion of water intake sites due to flooding • Impacts resulting from the rise in temperature (such as a rise in water demand and water quality deterioration due to an increase in algae)	• High poverty rate (30% in 2018 and 20% in 2020)
6) Sri Lanka	• The high non-revenue water rate is a major management problem. (In 2008, the non-revenue water rate was 54.1% in Colombo and about 33% across the country.) • Many water supply and distribution pipes are 75 to 100 years old. • Incomplete data. For example, many pipes and valves are not covered. • Undesirable status of piping, etc. (e.g., many inappropriate joints, many long bundles of water supply pipes, houses built above existing pipelines, and a densely populated area) • Illegal connections and imposition errors. Many public water faucets. • Each household has a tank before the water supply meter, causing a large loss.	• High energy loss associated with non-revenue water • Gradual rise in temperature, change in rainfall distribution patterns, and increases in the frequency and severity of extreme weather events	• Need for external support for house-to-house connections in poor households

Country	Water supply issues	Climate change issues	Other social issues
7) Brazil	• Efficient use and preservation are the most important issues because water resources are insufficient to cover the country's greatest water demand. • High non-revenue water rate (43.8% as of 2007)	• High energy loss associated with non-revenue water	• Water consumption in favelas (poor districts) is generally positioned as water consumption for social purposes and not included in calculating the non-revenue water rate. This consumption is difficult to know or anticipate. Measures involving city government, police, and other parties are required to promote non-revenue water reduction measures in favelas.
8) Cambodia	• Low water supply rates in regional cities (The population benefiting from urban water supply was about 30% of 80,000 people before the project.) • In addition to a water leakage rate of 20% to 35%, the total reach of water service pipes is insufficient to make use of increased supply capacity of enhanced water purification plants due to high non-revenue water. • Loss due to non-revenue water is also a major problem in the context of project operation. • High water supply pressure in pipes due to undulating terrain (Preah Sihanouk) • Frequent water leakage due to water pipes damaged during road expansion work (Pursat and Battambang)	• High energy loss associated with non-revenue water • Susceptible to extreme climate phenomena. Increasingly frequent floods and droughts.	• Particularly high poverty rate compared to other ASEAN countries (The poverty rate is estimated to be 30% to 50% across the entire region (cities and villages).)

1) to 8) indicate project numbers in Table 3-1.

Table 6 Climate Risks in the Water Business Relevant to Target Projects

Subject		Examples of climate risks	Grounds for relevance	1)	2)	3)	4)	5)	6)	7)	8)
Hard infrastructure	Expenses and spending related to water storage, water intake, water purification facilities, and water distribution facilities, etc.	Damage to facilities	High flood risk, damage already experienced	●	●			●			●
		Degradation of functionality	High flood risk, damage already experienced	●	●			●			●
		Intrusion of rainwater, sewage, etc.	High flood risk, damage already experienced	●	●			●			●
		Change in the annual operation, maintenance and management costs per unit of drinking water facilities	Rising electricity unit price		●	●	●	●			
Soft infrastructure	Organizations and people involved in projects	Degradation of adequate water supply capacity									
		Stoppage of adequate facility and equipment maintenance and management									
		Degradation of maintenance and management capabilities									
Surrounding environment	Access to water resources	Limitation on or lack of access to safe water	Population growth, water resource shortages, and water supply service imbalances	●	●	●	●	●	●	●	●
		Change in balance of water supply and demand	Increasing population		●	●	●	●			
		Change in the number of months without water shortage in a year and lowering or improvement of reliability resulting from the change	Regions with intermittent water supply	●	●		●	●			
		Change in the number of days with 12 hours or more of suspended water supply (cuts in water supply) in a year and improvement or lowering of reliability resulting from the change	Regions with an intermittent water supply	●	●		●	●			
	Sanitation	Increase in the incidence of waterborne infectious diseases	Lack of sewers, waterborne diseases, chlorine shortage	●	●		●				

Subject		Examples of climate risks	Grounds for relevance	1)	2)	3)	4)	5)	6)	7)	8)
		Fluctuations in the mortality rate of children under 5 years old (deaths per 1,000 live births) corresponding to changes in sanitary water supply	Lack of sewers, waterborne diseases, chlorine shortage	●	●		●				
	Source	Soil abrasion in water source basin									
	Water resources	Deterioration of water quality (changes in turbidity, BOC, phosphorus, nitrogen, etc.)	Lack of sewers, water quality deterioration	●	●			●			
		Limitation or suspension of water intake due to significant intrusion of soil and sand	High flood risk, damage already experienced	●	●			●			●
		Change in groundwater level or water quality	Use of groundwater, drop in groundwater level		●	●	●				
		Decrease in glaciers	Affected by glacial melting		●						
		Increase or decrease in annual available water resources	Drop in groundwater level, lowering of water availability expected, water quality deterioration at water sources, more frequent floods and droughts		●	●	●	●			●

1) to 8) indicate project numbers in Table 3-1.

2－4 Consideration of qualitative and quantitative assessments

(1) Assessment indices

This section provides an examination of qualitative and quantitative assessments of the effects of water supply development and climate change measures using support options. Regarding climate change measures, whereas numerical indices are often shown for activities related to mitigation strategies, many adaptation measures cannot be expressed as numerical indices. In this study, items are shown in the qualitative assessment section if quantitative assessment is difficult. It is also worth noting that qualitative assessment items and types of numerical indices for quantitative assessment differ depending on the implemented support option, that the accuracy of numerical data varies among countries and entities, and that some indices may not have been calculated. Therefore, it is difficult to simply compare and interpret even the same indices; the circumstances in each region must be considered during assessment.

1) Quantitative assessment

Numerical indices related to water supply issues, climate change measures, and other social issues reported to have changed as a result of the implementation of support options are extracted from data such as reports. Table 7 shows sample indices.

Table 7 Sample Indices for Quantitative Assessment

Category	Sample indices
Water supply indices	Water supply rate, water supply volume, population with access to water, water distribution volume per capita with access to water, daily water consumption per capita, water supply time, water leakage rate, non-revenue water rate, water quality, water pressure, current balance, the number of water supply training attendees, access rate to safe water.
Climate change measures indices	Power consumption, CO_2 emissions calculated from power consumption, power consumption per unit of water supplied, electricity price, the number of climate change training attendees.

2) Qualitative assessment

Possible effects of support options on water supply issues, climate change measures, and other social issues are extracted from reports and pigeonholed. Table 8 shows sample indices.

Table 8 Sample Indices for Qualitative Assessment

Category	Sample indices
Aspects related to water supply development	• Improvement of water storage, water intake, water purification facilities, and water distribution facilities, etc. • More accurate pipe, etc. drawings and water supply data • Development of each controller's knowledge and capabilities • Creation of guidelines, manuals, etc. • Building of personnel development frameworks • Decrease in waterborne diseases, etc. as a result of improving the quality of water supplied
Aspects related to climate change measures	• Constructing water supply systems resilient to droughts and floods • Action to address water salination at the water source • Action to address public health risks and change in water demand as a result of climate change • Behavioral change of residents through improvement to the quality of water supplied
Aspects related to other social issues	• Population change • Reduction in water-drawing labor by women and children • Living improvements in poor households.

3) Calculation of CO_2 emissions

In this study, the method in JICA Climate-FIT (mitigation strategies) is used to calculate CO_2 emissions from non-revenue water reduction indices.[19] Table 9 shows CO_2 emission factors of grid power used for the calculation. The CO_2 emission factor differs depending on each country, with Brazil having the smallest CO_2 emission factors for energy efficiency and power consumption. El Salvador, Jordan, and Pakistan also have smaller factors than Japan. The CO_2 emission factors are inversely proportional to the ratio of electricity with low CO_2 emissions (the ratio of power generated from nonfossil fuels). Brazil generates 91% of its power from natural sources such as hydroelectric facilities (IEA, 2022). The calculated amount of CO_2 emission reduction is small in countries with a high ratio of electricity with low CO_2 emissions, even if the reductions in power consumption are the same.

Table 9 CO_2 Emission Factors of Grid Power

(t-CO_2/MWh)

Country/region/island	Combined margin*1 grid emission factor				Operating margin grid emission factor (including that for calculating PCAF*2 GHGs)
	Stable energy (such as hydro and geothermal power)	Intermittent energy (such as solar, wind, and tide power)	Energy efficiency	Power consumption	
Brazil	0.150	0.234	0.150	0.150	0.284
Cambodia	0.588	0.874	0.588	0.588	1.046
El Salvador	0.275	0.445	0.275	0.275	0.547
Jordan	0.382	0.474	0.382	0.382	0.529
Pakistan	0.386	0.515	0.386	0.386	0.592
Rwanda	0.416	0.601	0.416	0.416	0.712
Sri Lanka	0.506	0.646	0.506	0.506	0.731
Japan	0.408	0.448	0.408	0.408	0.471

Source: Appendix 3 of JICA climate change measure support tool, JICA Climate-FIT, Version 4.0, March 2023 (translated into Japanese by the administrative office)
The values for the relevant country are selected considering the project type.

*1: The combined margin can be said to be more inclusive because it is calculated considering both the operating margin, which assumes that the project will replace electricity generated at existing power plants, and the build margin, which assumes that the project will delay the construction of a power plant.[20]

*2: PCAF (Partnership for Carbon Accounting Financials) is a global partnership of financial institutions cooperating to develop and implement a consistent approach to assess and disclose GHG emissions associated with loans and investments.

(2) Assessment results

Tables 10 to 17 show the examined results of qualitative and quantitative assessments on the effects of implementing support options in each target project. Unless otherwise indicated, the pre-implementation numbers represent the values in the year of the reference values in the title rows of the tables, and the post-implementation numbers represent the values in the actual years.

Table 10 Qualitative and Quantitative Assessments on the Effects of Implementing Support Options

1) Project for Strengthening the Business Operational Capacity of El Salvador's National Water and Sanitation Authority

Category	Item	Description of effects (reference value: 2011, result value: 2014)
Water supply development	Quantitative assessment	Revenue from the waterworks business: Increased from 82,107 million dollars to 84,598 million dollars
		Non-revenue water rate (model zone): Decreased from 43% to 28% (Zone inflow water volume (m^3/day) / Revenue water volume (m^3/day) / Non-revenue water volume (m^3/day) / Non-revenue water rate) Before the project: 4,903 / 2,818 / 2,085 / 43% After the project: 4,085 / 2,955 / 1,130 / 28%
		Non-revenue water rate (practical pilot zone): Decreased from 47% to 21% (Zone inflow water volume (m^3/day) / Revenue water volume (m^3/day) / Non-revenue water volume (m^3/day) / Non-revenue water rate) Before the project: 3,485 / 1,860 / 1,624 / 47% After the project: 2,583 / 2,050 / 533 / 21%
	Qualitative assessment	(Expansion of the scope of the Project for Reducing Non-Revenue Water) The Project for Reducing Non-Revenue Water for a new zone was created and implemented.
		(Budget allocation for non-revenue water reduction) A budget application was created according to the Project for Reducing Non-Revenue Water. The budget required for activity was allocated at ex-post assessment.
		(Strengthening of personnel capabilities to reduce non-revenue water) Capabilities related to non-revenue water reduction were strengthened and knowledge about non-revenue water disseminated. A framework to spread knowledge has been established. For example, a non-revenue water plan team was formed, and those who have received training share knowledge with other bureaus, and onboarding and other trainings are organized.
Climate change measures	Quantitative assessment	Power consumption: Increased from 508,376,770.47 kWh to 509,072,866.97 kWh. (The goal was not achieved partly because new projects in progress require power consumption.)
		Pilot facility 1 (Power factor capacitors were installed at power receiving/transforming facilities at the headquarters building.) • Electricity power factor value: Increased from 76.7% on average to 92.0% on average • Monthly average electricity price: Saved 1,223.83 dollars/month
		Pilot facility 2 (The discharge pressure is now controlled to a certain value by driving an inverter in one of two pump motors.) • Power consumption per sent unit of water flow: Reduced from 0.362 kWh/m^3 to 0.343 kWh/m^3 • Monthly average power consumption: Saved 15,992.5 kWh/month • Monthly average electricity price: Saved 1,200.30 dollars/month
		Pilot facility 3 (The discharge pressure is now controlled to a certain value by driving an inverter in pump motors.) • Power consumption per sent unit of water flow: Reduced from 0.272 kWh/m^3 to 0.231 kWh/m^3 • Monthly average power consumption: Saved 6,300 kWh/month • Monthly average electricity price: Saved 1,071.00 dollars/month
		Pilot facility 4 (Pump operation was reviewed. (The operating time was reduced.)) • Power consumption (nighttime and late-night slots): Reduced from 17,930 kWh/month to 8,366 kWh/month • Monthly average electricity price: Saved 675.70 dollars/month (about 11% of the rate before the project)
		Review of the filter basin washing method and correction of washing intervals • Annual electricity price: Saved 1,300 dollars/year
		Effects of eight power-saving projects in the power-saving plan proposal (including water distribution zoning in line with the Long-Term Project for Reducing Non-Revenue Water) • Annual amount of electricity (estimation): Reduced 44,306,035 kWh (8.7% of the power consumption in 2010 of 505,570,517 kWh) • Electricity price (estimation): Reduced 3,134,823 dollars/year • GHG emissions (estimate): Reduced 12,184 t-CO_2/year (44,306,035 kWh/year x 0.275 t-CO_2/MWh)

Category	Item	Description of effects (reference value: 2011, result value: 2014)
	Qualitative assessment	(Improvement in power consumption efficiency) Improved the power consumption efficiency through power-saving activities (energy saving and non-revenue water countermeasures).
		(Understanding and recognition of power saving) Improved awareness of cost reduction regarding power consumption of water facilities.
		(Introduction of power consumption measurement and analysis methods) Power consumption per sent unit of water flow (kWh/m^3) is now assessed as a consumption index.
		(Learning about power-saving methods) Power-saving methods were learned and a proposal for a power-saving measures plan was created, and a budget was applied for.
		(Implementation of water distribution network analysis) Networks of distribution and other pipes can now be analyzed by licensing 3D CAD software for civil engineering and hydraulic modeling software. The water distribution network was analyzed to consider water distribution zoning (in line with the Project for Reducing Non-Revenue Water).
Social issues	Qualitative assessment	(Creation of a sewer facilities maintenance planning manual) A sewer facilities maintenance planning manual that can be referred to in creating sewer plans was created and formally approved by the board.

Table 11 Qualitative and Quantitative Assessments on the Effects of Implementing Support Options

2) Project for Improving the Energy Efficiency of Water Supply Facilities in Lahore, Pakistan

Category	Item	Description of effects (reference value: 2013, result value: 2020)
Water supply development	Quantitative assessment	Total daily sent water volume (m^3/day): Increased from 261,349 m^3/day to 376,273 m^3/day
		Average daily operating time (hours/day): Decreased from 14.6 (hours/day) to 10.8 (hours/day) (12 hours in summer and 10 hours in winter from April 2019)
		Capacity of deep wells (m^3/ hours): Increased from 17,901 m^3/day to 34,776 m^3/day
	Qualitative assessment	(Reduction in maintenance and management costs due to scheduling preventive maintenance) A reduction in the number of pump failures has contributed to a reduction in maintenance and management costs.
		(Reduction in electricity cost) The electricity cost, which accounted for 40% of payments by the Lahore WASA, was reduced. However, electricity spending continues to pressure management due to a rise in electricity prices.
		(Improvements to the water supply service and building of trust) The number of regions experiencing poor water supply, such as a drop in water pressure or prolonged water suspensions, was reduced. This built trust with residents. However, some residents pointed out that houses far away from deep wells experienced low water pressure.
		(Improvement in the quality of water supplied) Installation of chlorine injection facilities and arsenic removal equipment (imposed on Lahore WASA) improved the quality of water supplied.
		(Reduction in water supply time) Pump operating time was gradually reduced because the groundwater level significantly dropped and electricity spending put pressure on management.
		(Improvement of sanitation and living) Improvement of the water supply service improved sanitary and living convenience.
Climate change measures	Quantitative assessment	Power consumption of well pumps (average energy efficiency) (kW/m^3): Reduced from 0.317 kWh/m^3 to 0.213 kWh/m^3
		Power consumption: reduction by 9,600 MWh (reduction by 32.8%)
		GHG emissions: Reduced by 3,706 t-CO_2/year (9,600 MWh/year x 0.386 t-CO_2/MWh) (Reduction in GHG emissions by 5,400 t-CO_2/year was calculated with a CO_2 conversion factor of 0.566 t-CO_2/MWh in the source report.)
		Power saving through preventing excessive water pumping (valve adjustment): 12,000 kWh/location and year, assuming 3 kW/location x 11 hours/day
		Restraint of electricity spending through improving energy efficiency: About 10%
		Number of people who received training on energy audit techniques: 30 people in the WASA energy management team in the maintenance and management section

Category	Item	Description of effects (reference value: 2013, result value: 2020)
	Qualitative assessment	(Improvement of energy audit techniques) The seven-member energy audit team (including the electricity manager) conducted energy audits, which helped to prevent of excessive water pumping, led to reporting to the operation and maintenance and management sections in case of failures, and led to decisions on pump update timing.
		(Organization of technical data) Technical data such as manuals and formats prepared for technical training assistance are used continuously.
Social issues	Qualitative assessment	(Drop in the groundwater level) The pump operating time was gradually reduced because the groundwater level significantly dropped. The actual groundwater level dropped more than expected in some deep wells.

Table 12 Qualitative and Quantitative Assessments on the Effects of Implementing Support Options

3) Project for Energy Conservation through Upgrading the Water Supply Network in the Hashemite Kingdom of Jordan

Category	Item	Description of effects (reference value: 2009, result values: 2018, 2019)
Water supply development	Quantitative assessment	• Water feeding capacity: Increased by 1,900,000 m^3/year
		• Water supply volume per capita: Decreased from about 140 L/day to 120 L/day in the Amman metropolitan area and Zarqa (2019). 100 L/day in other local city areas, 80 L/day in local village areas (2019). The water supply and demand are seriously falling out of balance due to causes such as population growth and the inflow of refugees, regardless of limited water resources.
	Qualitative assessment	(Enhancement of the abilities of operation, maintenance and management personnel) Technical support, enhanced knowledge, and skills related to pump operation and maintenance and management by implementing agency personnel (efficient operation of pump equipment and reliable implementation of periodic maintenance and management work). In particular, the custom of preparing for maintenance and management and accurate monitoring was learned by attending all preventive maintenance trainings.
		(Stabilization of water supply and distribution) Failures and disruption of water feeding were reduced in water service facilities.
		(Improvement of the water supply situation) An increase in the amount of water sent to the distribution reservoir increased the amount of distributed water and improved the water supply situation in the water distribution area.
		(Management of sent water through identification of flow rate) Installation of flowmeters made it possible to accurately identify the flow rate, which enabled management of the sent water volume and amount of water leakage, as well as management of pump operation diagnostics.
Climate change measures	Quantitative assessment	• Electricity consumer per unit of water supplied (kWh/m^3): Azraq pumping station (Khaw distribution reservoir): Reduced from 1.88 kWh/m^3 to 1.48k kWh/m^3 (2018) Hallabat pumping station (Khaw distribution reservoir): Reduced from 0.62 kWh/m^3 to 0.50 kWh/m^3 (2018) Hallabat pumping station (Hallabat village): Reduced from 1.20 kWh/m^3 to 0.63 kWh/m^3 (2018) Zarqa pumping station (Batrawi distribution reservoir): 0.78 kWh/m^3 to 0.40 kWh/m^3 (2018)
		• Operating efficiency (%): Azraq pumping station (Khaw distribution reservoir): Increased from 57% to 68% (2018) Hallabat pumping station (Khaw distribution reservoir): Increased from 57% to 68% (2018) Hallabat pumping station (Hallabat village): Increased from 34% to 65% (2018) Zarqa pumping station (Batrawi distribution reservoir): Increased from 50% to 68% (2018)
		• Power consumption (annual): Reduced by 8,687 MWh or more (about 18% of the total electricity consumption by the target pumping station before the project) (2019)
		• GHG emissions: Reduced by 3,318 t-CO_2/year or more (8,687 MWh/year x 0.382 t-CO_2/MWh) (2019)

Category	Item	Description of effects (reference value: 2009, result values: 2018, 2019)
		(Reduction in GHG emissions by 5,386 t-CO_2/year or more was calculated with a CO_2 conversion factor of 0.62 t-CO_2/MWh in the source report.)
		• Electricity costs: Reduced by 999,000 JOD or more (2019)
	Qualitative assessment	(Saving of energy consumed for water supply and distribution, and electricity price) Power consumption accounts for about 60 to 70% of total operating, maintenance and management costs. Because almost all electricity depends on thermal power generation, reducing electricity consumption also contributes to reducing GHG emissions.
		(Establishment of a gravity-flow system) Water amount allocation scenarios were set in the water supply and distribution plan for a gravity-flow system that has eight water distribution zones and starts from the distribution reservoir.
		(Enhancement of the abilities of operations, maintenance and management personnel) Personnel in the implementing agency gained knowledge and technical skills to enable efficient operation of pump equipment as well as operation and management of the water conveyance system.

Table 13 Qualitative and Quantitative Assessments on the Effects of Implementing Support Options

4) Secondary Project for Improving the Water Supply Facilities in the Zarqa Area of the Hashemite Kingdom of Jordan

Category	Item	Description of effects (reference value: 2005, result value: 2010, 2011, 2012)
Water supply development	Quantitative assessment	• Estimated population with access to water: From 329,540 to 382,000 (2010), 390,000 (2011), 400,000 (2012)
		• Estimated population without access to water: From 6,725 to 0 (2010, 2011, 2012)
		• Water supply rate: From 98% to 100% (2010, 2011, 2012)
		• Water supply time: From 12 to 72 hours/week to 72 hours/week
		• Water leakage rate: From 31% to 23.5% (2010), 25.0% (2011), 24.5% (2012)
		• Average daily water consumption per capita: From 84 L/person a day to 126 L/person a day (2010), 128 L/person a day (2011), 116 L/person a day (2012)
		• Water supply pressure: From 0–10 bar to 1.5–5.5 bar (2010, 2011, 2012)
		• Number of training attendees: Training on the water distribution network mapping program and water distribution data management capacity program: 11 GIS training: 6 Training on the water distribution network analysis program: 13 EPANET (pipe network analysis software) training: 7 Seminar on the water distribution network analysis model: 50
	Qualitative assessment	(Shift to gravity flow) Pressurized pumping shifted to gravity-flow water distribution as a result of distribution reservoirs and laying of water pipes, leveling the water supply pressure for efficient water distribution.
		(Expansion of water distribution areas) A sufficient amount of water is now distributed to remote places in the same regions compared to before the project starting.
		(Simplification of maintenance and management) Maintenance and management was simplified by designing facilities that avoiding, to the extent possible, the need to install pumping stations.
		(Establishment of a chlorination framework) Chlorination equipment was installed at the pumping stations, strengthening the chlorination framework along with the water intake source.
		(Strengthening of water distribution management capability) Training and seminars on the water distribution network mapping program, water distribution data management, pipe network analysis, and other topics were held for responsible personnel. Attendees can now leverage water distribution data, run water distribution network simulations, and understand the hydraulic situation, for instance.
		(Establishment of a training framework) At training facilities, training is organized as needed in addition to periodic technical training for personnel.
		(Satisfaction of residents) Whereas about 50% of the respondents expressed satisfaction with the project, the remaining 50% either answered with neither satisfied nor dissatisfied or expressed dissatisfaction. One of the main reasons is

Category	Item	Description of effects (reference value: 2005, result value: 2010, 2011, 2012)
		likely to be that the northern area of Zarqa has a high concentration of houses but many aging water service pipes. This is an area where dissatisfaction with the water supply for reasons such as water leakage and water supply pressure continue to be observed. At least 75% of respondents answered that the water supply volume had increased.
Climate change measures	Quantitative assessment	• Estimated increase and decrease in the annual electricity consumption by pumping stations with or without the project Reference value: 2,134,382 JOD/year (2004), electricity costs per sent water volume unit: 0.0334 JOD/m^3 (2004) Estimated value: 2,319,504 JOD/year with the project (2010) and 2,720,649 JOD/year without the project (2010) • GHG emissions (estimation): Reduced by 3,737 t-CO_2/year (9,784 MWh/year x 0.382 t-CO_2/MWh)
	Qualitative assessment	(Reduction in other behaviors to obtain water) Residents stopped buying water from private dealers. This is expected to result in a reduction in related energy consumption.
		(Energy reduction as a result of the change to the water distribution route and shift to gravity flow) Creating water distribution zones and separating the water supply and distribution system realized an efficient pump operation. Shift from pressurized pumping to the water distribution using gravity flow reduced power consumption and electricity costs.
Social issues	Qualitative assessment	(Decrease in water-drawing labor) A large percentage of respondents answered that work and time for water drawing, transportation, etc. decreased.
		(Improvement in hygiene and decrease in diseases) Responses to questions about diarrheal diseases, etc. and improvement in hygiene were generally positive.

Table 14 Qualitative and Quantitative Assessments on the Effects of Implementing Support Options

5) Master Plan Project of Waterworks Improvement and Maintenance in Kigali, Rwanda

Category	Item	Description of effects (target values)
Water supply development	Quantitative assessment	(Master scenario) • Water purification capacity: Increased by 142,000 m^3/day (2019), 207,000 m^3/day (2020) and expected to be increased by 85,000 m^3/day by 2025, 98,000 m^3/day from 2025 to 2035, 754,000 m^3/day toward 2050
		• Water supply penetration rate (individual water taps): From 25% (2019) to 100% (2050)
		• Penetration rate, attributed to the availability of public water faucets: From 16% (2019) to 0% (2050)
		• Non-revenue water rate (regarded as water leakage rate): From 35% (2019) to 25% (2025), 23% (2035), 20% (2050) (The master scenario simulation for 2025 is planned based on the expected water demand, assuming a non-revenue water rate of 25%)
		(Target FS value in the priority project (expansion of the Karenge water purification plant) (to be completed in FY2026)) • Water purification plant capacity: Increased from 12,000 m^3/day (15,000 m^3/day by overloaded operation) to 48,000 m^3/day
		• Population with access to water: The entire target beneficiary population will increase to about 493,500 (2030) from 127,000 people who use improved water sources (2018)
		• Water supply rate (total of individual household connections and public water faucets): From 80% in Kigali and 46% in Eastern Province (EICV V (2018)) to 100% after completion of the project
		• Non-revenue water rate: From current 38.8% in Kigali to 25% (2025), 23% (2035)
		• Operating, maintenance and management costs: Reduced from 346 RWF/m^3 (existing Karenge water purification plant) to 263 RWF/m^3
		(Target FS value in the priority project (construction of the Masaka water purification plant) (to be completed in FY2026 at earliest)) • Water purification plant capacity: Increased to 20,000 m^3/day (Redundant water, if any, is sent to other regions.)
		• Population with access to water: Increased from 26,000 (35% of 75,000 (2021)) to

Category	Item	Description of effects (target values)
		169,000 (2035)
		• Water supply rate (total of individual household connections and public water faucets): From 80% in Kigali and 46% in Eastern Province (EICV V (2018)) to 100%
		• Non-revenue water rate: From current 38.8% in Kigali to 25% (2025), 23% (2035)
		• Operating, maintenance and management costs: Reduced from 346 RWF/m^3 (existing Karenge water purification plant) to 198 RWF/m^3
	Qualitative assessment	(Creation of the master plan with a high-level goal of improving the supply of safe and affordable drinking water) • The state of existing water facilities and water supply service was analyzed and assessed. • A future water demand forecast and water resource utilization plan were created. • A master plan was created and FS was conducted for selected priority projects. • Technology transfer was done through master plan creation work.
		(Action for a surging urban population) A method of mapping regions with planned water supply limitations and regions without water supply due to a pressure shortage in the GIS was devised for monitoring.
		(Securing of consistency with high-level and related plans) The goal is to achieve a 100% house-to-house water supply by 2050.
		(Water pressure control in the water supply and distribution system, and improvement of non-revenue water and energy efficiency) The water distribution zoning system was adopted to properly manage the water pressure and contain failures in the water supply due to low water pressure and water leakages due to high water pressure, and stabilize the water supply, thereby helping to improve the residents' living environment.
		(Strengthening of finance and organization) Measures for strengthening and improving finance and organization were recommended toward realizing a long-term plan. Securing budgets for human development for this purpose was also recommended.
		(Improvement in the quality of water supply pipe connections) Proposals for technical standards were created, emphasizing the importance of updating low-quality water supply pipes.
Climate change measures	Quantitative assessment	(Approximate FS value in the priority project (expansion of the Karenge water purification plant)) • Electricity consumed per unit of water supplied: Reduced from 1.74 kWh/m^3 (existing Karenge system) to 1.51 kWh/m^3 • GHG emissions: Increased by 7,042 t-CO_2/year (from 3,963 t-CO_2/year to 11,005 t-CO_2/year) • GHG emissions (compared to the scenario without improvement in energy efficiency): Reduced by 1,676 t-CO_2/year
		(Target FS value in the priority project (construction of the Masaka water purification plant)) • Electricity consumed per unit of water supplied: Reduced from 1.74 kWh/m^3 (existing Karenge system) to 0.81 kWh/m^3 • GHG emissions: Increased by 2,460 t-CO_2/year • GHG emissions (compared to the scenario without improvement in energy efficiency): Reduced by 2,824 t-CO_2/year
	Qualitative assessment	(Review of water operations (change of sent water route)) A pressurizing pumping station is constructed in the middle of the hill to distribute most of the water supply using gravity flow, which significantly reduces energy costs compared to sending all water to the distribution reservoir up on the hill.
		(Resilience to disasters) The limited water resources are protected by reducing water leakage, and measures such as pipe updates and valve installation modify the water supply system for a more stable water supply. Operating, maintenance and management capabilities for water safety planning and water purification treatment are improved.

Table 15 Qualitative and Quantitative Assessments on the Effects of Implementing Support Options

6) Project for Strengthening the Capability to Reduce Non-Revenue Water in Colombo, Sri Lanka

Category	Item	Description of effects (reference value: 2012, result value 2015)
Water supply development	Quantitative assessment	• Non-revenue water rate in Colombo: Decreased from 49.5% to 45.9%
		• Decrease in the non-revenue water rate: 1.2 percentage points/year (2012 to 2015, Colombo). The target annual rate of 1.0 percent point was achieved.
		• Number of seminar and workshop attendees: 520
		• Non-revenue water rate in each pilot area (Area name: Rate before the project/rate after the project): K1: 85%/56% K2: 78%/72% K3&K4: 73%/71% K6: 45%/- B1: 40%/18% B2: 62%/- B3: 84%/29% B4-1: 60%/27% B4-2: 62%/52% B5: 62%/- B6: 50%/28%
	Qualitative assessment	(Expansion of non-revenue water reduction activities) Non-revenue water reduction activities were expanded to 22 areas in Colombo, in accordance with the non-revenue water countermeasures deployment plan.
		(Budget allocation for non-revenue water reduction activities) Whereas efforts such as water pipe replacement and water meter installation were performed with assistance from JICA and the ADB, NWSDB has allocated a budget to repair water leakage.
		(Reflection to the project plan) A non-revenue water countermeasures deployment plan that helps to achieve target values in the corporate plan was created and reflected in the NWSDB project plan.
		(Establishment of a personnel development framework) A training program for non-revenue water reduction was organized for non-revenue water reduction teams, which not only continue non-revenue water reduction activities in pilot areas but also play a leading role in spreading the activities across Colombo. The manual developed in this project has been widely used.
		(Establishment of a framework and implementation of activities) Non-revenue water reduction teams were organized in two pilot areas, and they implemented non-revenue water reduction activities according to the work plan.
		(Preparation of drawings) Drawings were updated and the GIS was introduced.
		(Enhancement of personnel technical skills) Engineers and workers in non-revenue water reduction teams gained appropriate skills for examining water leakage, connecting old rainwater pipes, and maintaining pipes.
		(Non-revenue water reduction through identifying flow rate) Non-revenue water other than water leakage was also reduced by installing or replacing meters and digging up illegal connections.
		(Implementation of appropriate measures for the conditions) It was confirmed that the effects of non-revenue water countermeasures depend on the pipe status. Therefore, if pipe status was poor, effects were achieved by combining disconnection or reconnection of long, bundled water supply pipes with water leakage measures.
		(Service quality improvement and revenue increase) Positive effects such as reduction in water production costs, improvement in water distribution system performance, and increase in the number of customers were observed, which helped to improve the quality of NWSDB services and led to higher revenue.
Climate change measures	Quantitative assessment	• GHG emissions (drop in the non-revenue water rate across Colombo (2007-2010)): Reduced by 865 t-CO_2/year (distributed water volume of 115,000 m^3/day, electricity consumed per unit of water supplied of 0.570 kWh/m^3*)
	Qualitative assessment	(Energy consumption reduction) Reduced water leakage led to lower energy consumption.

* The annual amount of distributed water and electricity consumed per unit of water supplied were calculated by extracting related values in the 2012 NWSDB annual report.

Table 16 Qualitative and Quantitative Assessments on the Effects of Implementing Support Options

7) Non-Revenue Water Management Project in Brazil

Category	Item	Description of effects (reference value: 2007, result values: 2010, 2013)
Water supply development	Quantitative assessment	• Non-revenue water rate (IPM): Across SABESP: Reduced from 35.8% to 32.3% (2010), 31.2% (2013) Urban areas: Reduced from 34.6% to 31.9% (2010), 30.8% (2013) Rural areas: Reduced from 39.1% to 33.3% (2010), 32.3% (2013)
		• Non-revenue water rate in each pilot area (IPM): MO area: Reduced from 59% to 22% (2010) RS area: Reduced from 31% to 28% (2010) RV area: Reduced from 62% to 30% (2010)
	Qualitative assessment	(Improvement of non-revenue water management capability) An 11-year non-revenue water reduction and improvement in energy efficiency program has been implemented since its creation in 2009, based on a Project for Reducing Non-Revenue Water developed by 15 business units using skills obtained through the project.
		(Strengthening of human resource development related to non-revenue water management) A training program consisting of 13 courses under four themes was created. The SABESP has started disseminating results to other business units since the end of the project.
		(Enhancement of fundamental measures) Electromagnetic flowmeters were installed and the amount of distributed water was measured in all the pilot areas by the time the project was complete. The causes of non-revenue water were sufficiently located in the pilot areas. Technology transfer in the business unit is also active.
		(Adjustment of data management) The manager in each business unit has maintained and managed GIS data. Data related to non-revenue water management can be extracted and managed.
		(Strengthening of post-measures after maintenance, etc.) Supportive measures such as water leakage detection in water service pipes, watertightness inspections in water supply pipes, repair of water service pipes and water supply pipes are actively taken in other areas, which have leveraged insights and experience gained in pilot areas.
		(Strengthening of preventive measures) Water supply pipes and water service pipes were replaced mostly according to plan. Water pressure was also adjusted in two areas where it was needed. A low-cost, highly sustainable water pressure adjustment method was adopted and has been continuously implemented in areas without equipment for automatic detection and adjustment. Although patrol efforts were not achieved due to a workforce shortage, a proposal to take photos of work progress for better work efficiency was also adopted during ex-post assessment. This helped to strengthen the preventive measures.
		(Strengthening of construction management) Construction management courses were created in the training program, and methods for constructing water supply pipes and for managing such construction were standardized.
Climate change measures	Quantitative assessment	• GHG emissions (drop in the non-revenue water rate across SABESP (2007-2010)): Reduced by 17,454 t-CO_2/year (distributed water volume of 7,776,000 m^3/day, electricity consumed per unit of water supplied of 0.752 kWh/m^3*)
	Qualitative assessment	(Energy consumption reduction) Reduced water leakage led to lower energy consumption
Social issues	Qualitative assessment	(Non-revenue water management in favelas (poor districts)) It was basically impossible to manage non-revenue water in favelas through this project, and no concrete action has been taken. In this project and in the non-revenue water management yen credit project, attempts have been made to install flowmeters at the positions of inflow to favelas to identify the volume of water supplied.

* To prepare for the non-revenue water countermeasures project in Sao Paulo, Brazil (February 2010), the electricity consumed per unit of water supplied was calculated by extracting related values in the main and supporting final reports on the survey.

Table 17 Qualitative and Quantitative Assessments on the Effects of Implementing Support Options

8) Project for Repairing and Expanding Water Service Pipes in Provincial Capitals in Cambodia

Category	Item	Description of effects (reference value: 2009, result value 2016)	Description of effects (reference value: 2011, result value 2016)
Water supply development	Quantitative assessment	(Pursat) • Non-revenue water rate (%): 23 10 • Water purification plant operating rate (%): 59 95 • Charge collection rate: 114 181 • Maximum daily water supply volume (m^3/day): 3,410 6,864 • Population with access to water: About 18,200 36,310	(Pursat) • Water supply rate from the urban water supply: 54.8 50.5 • Minimum dynamic water pressure (kPa): 150 100 • Maximum dynamic water pressure (kPa): 200 150
		(Preah Sihanouk) Non-revenue water rate (%): 19 16 • Water purification plant operating rate (%): 81 20 • Rate of water purchased from outside (%): 0 61 • Charge collection rate: 153 - • Maximum daily water supply volume (m^3/day): 6,200 13,743 • Population with access to water: About 23,000 68,404	(Preah Sihanouk) • Water supply rate from the urban water supply: 33.5 53.0 • Minimum dynamic water pressure (kPa): 200 200 • Maximum dynamic water pressure (kPa): 700 700
		(Battambang) • Non-revenue water rate (%): 36 10 • Water purification plant operating rate (%): 80 88 • Charge collection rate: 149 180 • Maximum daily water supply volume (m^3/day): 9,220 16,242 • Population with access to water: About 42,900 71,255	(Battambang) • Water supply rate from the urban water supply: 27.1 37.7 • Minimum dynamic water pressure (kPa): — 80 • Maximum dynamic water pressure (kPa): 75 220
	Qualitative assessment	(Improvement in water volume and water pressure deficit) The water volume and water pressure deficit were improved at water faucets because an adequate water supply pressure is now maintained in water service pipes.	
		(Reduction in the non-revenue water rate) Reduced water leakage led to a fall in the rate of non-revenue water. However, there are still the use of old steel pipes (Pursat, Battambang), damage to water pipes due to road expansion work (Pursat, Battambang, Preah Sihanouk), and water leakage from joints, which is likely to be caused by a rise in the water pressure in water supply pipes due to rough terrain (Preah Sihanouk).	
		(Management improvement) An increase in water supply revenue resulting from a rise in the number of customers and a decline in water leakage, as well as a reduction in fuel expenses (Pursat) and chemical and other material fees, contributed to the improvement of management at each Waterworks Bureau.	
		(Water distribution network monitoring) The water distribution network is properly managed. However, granted water distribution flow rate monitoring systems failed at ex-post assessment in Battambang and Preah Sihanouk.	
		(Enhancement of water supply pipe connection skills) Technical assistance was provided, enhancing water supply pipe connection skills.	
		(Use of water purification plant capacity) The capacities of water purification plants enhanced and developed through donor support can now be effectively leveraged as the water distribution network is established.	
		(Capability building through contribution to the technical cooperation project)	

Category	Item	Description of effects (reference value: 2009, result value 2016)	Description of effects (reference value: 2011, result value 2016)
		Technology transfer related to the operation and maintenance of water purification plants and support for management capability strengthening in a technical cooperation project conducted at the same time led to large benefits from the project.	
Climate change measures	Quantitative assessment	(Pursat) • Water supply energy efficiency (kWh/m^3): — 0.429 • Diesel consumption efficiency (L/m^3): 0.222 0.152 • GHG emissions (drop in non-revenue water rate): Reduced by 53 t-CO_2/year*	
		(Preah Sihanouk) • Water supply energy efficiency (kWh/m^3): 0.704 1.008 • GHG emissions (drop in non-revenue water rate): Reduced by 34 t-CO_2/year* • GHG emissions: Increased by 2,036 t-CO_2/year • GHG emissions (compared to the scenario without improvement in energy efficiency): Increased by 897 t-CO_2/year	
		(Battambang) • Water supply energy efficiency (kWh/m^3): 0.609 0.41 • GHG emissions (drop in non-revenue water rate): Reduced by 490 t-CO_2/year* • GHG emissions: Increased by 224 t-CO_2/year • GHG emissions (compared to the scenario without improvement in energy efficiency): Reduced by 694 t-CO_2/year	
	Qualitative assessment	(Reduction in fuel costs as a result of the shift to grid power) In Pursat, fuel costs were reduced partly because the power source for pumps, etc. was shifted from generators to public grid power.	
		(Improvement in energy efficiency) A reduction in water leakage led to a fall in the electricity consumed per unit of water supplied. However, energy efficiency did not improve in Preah Sihanouk because the water purification plant continues to operate in emergencies even though most of the supplied water is purchased from outside (private water supply companies).	
Social issues	Quantitative assessment	(Pursat) 400 new households were connected and 700 households were reconnected.	
		(Preah Sihanouk) In 2014, the water supply was connected to 600 new households.	
		(Battambang) By January 2017, the water supply was connected to 1,124 new households. The plan was to connect the water supply to another 376 households using remaining materials by the end of 2017.	
	Qualitative assessment	(Changes in the living standards of people living in poverty due to having a safe water supply) Respondents answered that safe water is now available whenever needed without the necessity of water-drawing labor (80%); Water is safe and reliable (about 69%); There are economic benefits (about 26%); Health status has improved (6%).	

* GHG emissions resulting from a drop in the non-revenue water rate were calculated using the amount of distributed water before the project and assuming that the water supply energy efficiency before the project remains unchanged even after the project. However, the value after the project was used for Pursat because the water supply energy efficiency before the project was unknown.

Next, the water supply development, climate change measures, and social issues are categorized by item, and the items for which implementation of the support options provided benefits in each project are organized in Table 18 to examine the synergistic effects of each support option. The table has been created under the following conditions:

- For project 5), items for which implementation of the created plan is expected to provide benefits are organized.
- Items are marked if references such as reports contain a description of quantitative assessment or qualitative assessment.
- The assessment of effects on social issues is based on the results of a benefit investigation.
- Items are shaded if beneficial effects are not listed but still expected.
- Energy consumption resulting from extension and expansion of water facilities is compared with

energy consumption arising from the extension and expansion of facilities of the same scale without improvement in energy efficiency provided by the support options.

- Negative impacts due to changes in external environment, such as rises in electricity unit prices, surging water supply target populations, or an increase in other project activities not related to support options, are not included in this study's assessment.

The following viewpoints are added to the assessment of individual target examples.

- In target example 2), the ground water level was reported to have dropped due to an increase in the amount of pumped ground water in the water source. Support options have been implemented, adjusting the water supply time to minimize the drop.
- In target examples 5) and 8), although energy consumption increases in proportion to a rise in the water supply volume resulting from the expansion or addition of facilities, thereby lifting GHG emissions as well, it can be assessed that GHG emissions are reduced compared to expansion or addition without improvement in energy efficiency. (However, in the example of Preah Sihanouk in Table 17, most of water supplied is purchased from private-sector companies based on a contract. Because electricity is consumed to run the purification plant even though the water purification capacity is low, the energy efficiency has not improved.)
- In target examples 4) and 8), where there were effects on social issues, an increase in the water supply volume and service improvement have reduced water-drawing labor and the economic burden on households. Implementation of support options led to the formation of the sewage system establishment project in example 1). In target example 4), the residents' questionnaire showed a positive view on hygiene improvement. This means a stable supply of safe water can lead to improvement in the hygiene environment even in target examples where it is not mentioned in the quantitative and qualitative assessment.
- As in target examples 4) and 8), if the water supply service area expands, energy consumption and environmental impact for other means of acquiring water used due to the lack of a service are expected to decline.

Table 18 Synergistic Benefits from the Implementation of Support Options

Subject	Category	Item	Projects							
			1)	2)	3)	4)	5)	6)	7)	8)
Water supply development	Capabilities of facilities and equipment	Population with access to water			●	●	●	●		●
		Water supply rate				●	●	●		●
		Water supply volume		●	●		●			●
		Water supply volume and water consumption per capita				●				
		Water supply time				●	●			
		Water leakage rate	●			●	●	●	●	●
		Non-revenue water rate	●			●	●	●	●	●
		Quality of water supplied		●		●				
		Water pressure		●		●	●		●	●
	Expenses and spending	Reduced operating, maintenance and management costs	●	●	●	●	●	●		●
		Better management	●	●	●	●	●	●		●
	Organizations and people involved in projects	Better facility maintenance capabilities	●	●	●	●	●	●	●	●
		Improved planning capability	●				●	●	●	
		More accurate drawings and data						●	●	
		Creation of guidelines, manuals, etc.						●	●	
		Building of a human development framework	●			●	●	●	●	
	Access to water resources	Rate of access to safe water					●			
		Decrease in water service suspensions and intermittent water supply		●	●	●	●			
		Higher trust in the water business		●		●				
	Sanitation	Better living environment through supply of clean water		●		●	●			●
		Decrease in health damage due to supply of clean water				●				●
	Water resources	Impact on the water quality of the water source								
		Change in groundwater level		▲						
		Securing of water resources sustainability		●	●		●			
Climate change measures	Electricity use efficiency	Reduced power consumption per unit quantity of water	●	●	●		●			●
	Power consumption (reduction in CO_2 emissions)	Reduction in the energy consumption of water facilities	●	●	●	●	●			●
		Energy saving for water supply and distribution	●	●	●	●	●	●	●	●
		Reduction in energy consumption as a result of residents' behavioral change				●				●
	Expenses and spending	Reduced electricity consumed per unit of water supplied	●	●	●	●	●	●	●	●
	Water supply resilient to climate change	Higher resilience of facilities to heavy rains and floods					●			
		Action to address risks and change in water demand as a result of climate change					●			
	Organizations and people involved in projects	Enhanced abilities related to climate change measures	●	●	●	●	●	●	●	●
		Creation of guidelines, manuals, etc.	●	●				●	●	
Social issues	Gender, education, poverty	Reduced water-drawing labor, etc.				●				●
	Poverty	Higher living standards in poor households								●

Subject	Category	Item	Projects							
			1)	2)	3)	4)	5)	6)	7)	8)
	Health	Improved hygiene				●				

●: Beneficial, ▲: Negative impact. 1) to 8) indicate project numbers in Table 3-1.

2－5 Consideration of the Feasibility of Simultaneously Exploring Sustainable Water Supply Development and Climate Change Measures

This section considers how the water business should be conducted in order to supply safe water in a stable and sustainable manner in the future in countries that receive development cooperation assistance. For sustainable water supply development to improve water access for people without access to safe water, recognition of climate change risks, impacts of which are already known and those that could arise in the future, are essential. In addition, the water business must be resilient to such impacts. At the same time, there is a need to reduce GHG emissions from the projects as much as possible to help mitigate climate change.

Among the target examples in this chapter, climate change has caused prolonged dry seasons as well as obvious changes in river water turbidity and water volume due to heavy rains, floods, soil abrasion, torrential downpours, etc. during wet seasons in Kigali, in the Republic of Rwanda. In addition, the city faces issues due to its inherent rugged hills. For example, large amounts of energy must be consumed to distribute the water, and the high pressure in the water distribution network is difficult to manage, resulting in frequent water leakages. Therefore, both of these issues must be addressed to ensure that people in the Republic of Rwanda can access the water supply service in the future. (For the field study and the current situation in the Republic of Rwanda, refer to Chapter 3.)

To consider the feasibility of balancing sustainable water supply development and climate change measures, issues surrounding the water business, measures for improvement, and obtained benefits are organized from short-term and long-term perspectives, and the results of individual points to consider are shown in Table 19. The short-term perspective is roughly intended for 2030, which are SDG goals, and the long-term perspective is roughly intended for 2050, as often mentioned in IPCC reports. The short-term perspective covers issues to address through international cooperation activities and benefits from implementing measures. On the other hand, the long-term perspective can be regarded as establishing environment improvements and developing human capabilities that related parties must think about and work on by themselves.

Table 19 Issues, Measures, Benefits, etc. from Short-Term and Long-Term Perspectives

Item	Short-term perspective	Long-term perspective
Subject	Water business	Water business, supply chains, and entire society
Issues (including possibilities)	(Water supply development) • High water leakage rate • Shortage of facility capacity • Low water pressure • Shortage of water resources • Low charge collection rate • Difficulty revising water rates (Climate change measures) • Action to address aggravating floods and droughts caused by climate change • Burden of high electricity prices (Social issues) • Population change	(Water supply development) • Aging of facilities • Change in the availability of water sources (Climate change measures) • Further aggravation of climate hazards • Limitation of usable electricity (electrification using renewable energy) • Possibility of price rises of fossil fuels and fossil fuel-derived electricity due to carbon pricing • Change in usable materials and equipment (Materials and equipment with low life-cycle cost must be selected, considering the impact of carbon pricing.) • Need to strengthen sustainability awareness and consider ESG factors in financing (Social issues) • Population change
Improvement measures	• Capacity improvement of existing facilities and expansion of facilities • Preparation of data and drawings and flow-rate measurement through meter installation • Action to address water leakage (such as improvement of water leakage detection techniques and pipe update/construction techniques, as well as water pressure control through zoning) • Higher energy efficiency through equipment updates • Power-saving activities • Change in billing systems (change from a fixed-rate system to a metered-rate system through meter replacement or installation) • Creation of guidelines and manuals • Building of human development framework • Activities to promote customers' understanding and transform their awareness • Control and reduction of fatalities from waterborne infectious diseases	• Creation of development plans for water supply systems that have a lower environmental impact • Design of energy-efficient facilities such as gravity-flow systems • Shift to materials and equipment that have a lower environmental impact • Selection of low-risk water sources in terms of vulnerability to climate change • Expansion of renewable energy use • Consideration of water management methods from a broader perspective, such as through comparison with use of rainwater and reuse of treated sewage • Revision of land utilization plans and design standards in light of aggravation by climate hazards • Source protection and vegetation retention in upper river catchments • Building of human development frameworks • Activities to promote customers' understanding and transform their awareness • Control and reduction of fatalities from waterborne infectious diseases

Item	Short-term perspective	Long-term perspective
Direct benefits	• Reduction in power consumption and CO_2 emissions • Reduction in electricity price • Increase in the water supply amount and population with access to water through effective use of water resources • Decrease in damage to water supply service pipes • Decrease in maintenance and management costs	• Maintenance and improvement water supply rates • Reduced long-term maintenance and management costs • Reduced power consumption and CO_2 emissions by the water business • Improved resilience of the water business to climate change • Improved water resource sustainability
Indirect benefits	• Decreased use of bottled water and water-supply trucks as alternatives to tap water • Decreased wasteful water use • Decreased pump use as a result of preventing low water pressure caused by uneven water use	• Reduced CO_2 emissions from the supply chain and society as a whole • Action to restrict exports of products that use water on grounds of CO_2 emissions, etc.
Points to note	• Short-term cost benefits may disappear in the long term. • Because expansion of facilities increases CO_2 emissions, select strategies that limit emissions as much as possible. • Pay attention to the sustainability of water sources. • The calculated CO_2 emissions reduction effects of reducing power consumption will be small if the used power source has low CO_2 emissions. Therefore, proper assessment indices must be selected.	• Implement measures when facilities are updated. Proper planning and preparation are required. • Facilities must continue to be properly maintained and managed so that climate change measures will remain beneficial over the long term. • When considering urban water management, a wide range of collaborations is required rather than with the water business alone. • Financing is important for measures with high introduction costs. • Human resources must be secured and developed to implement the measures.

Although benefits from water supply development and costs could be seen in past basic plans (master plans) for water supplies, it is now necessary to adopt the viewpoint of climate change measures as an important criterion when proposing alternatives.

Efforts with clear direct benefits such as those in the short-term perspective column in the table (e.g., reductions both in GHG emissions and energy costs through energy saving) are easy to introduce. Meanwhile, to gain benefits listed in the long-term perspective column, be sure to consider how to reduce environmental impacts across the water supply system from a broader perspective during the development planning stage. Examples of these perspectives are shown below.

- (Changes in assessment points when selecting the water source) Factors such as the amount of water to be secured, the water quality of the water source, and transportation energy that depends on positional relationships are considered when the water supply source is selected. The balance of these factors may need to be considered in the context of reducing GHG emissions. For example, some target examples have options such as the use of rainwater as a water source in urban areas, or reuse of treated sewage. A possible increase in the need for energy-efficient systems (e.g., using gravity flow for water distribution whenever possible) and the necessity for water supply systems less vulnerable to climate change must be also taken into account.

- (Need for support plans that take the timing of facility updates into account) Investing in infrastructure facilities requires a substantial amount of capital. Consequently, making such investments to introduce new facilities or technologies is infrequent. You must factor in time to update facilities not omit opportunities to do the updates.
- (Consideration of long-term cost changes) When comparing alternative proposals, consider factors such as a possible price rise of fossil fuels or fossil fuel-derived electricity or products due to carbon pricing. Although developing nations tend to prioritize short-term cost effectiveness, alternatives that currently appear advantageous in terms of cost might not necessarily remain so from the viewpoint of a long-term lifecycle.
- (Broader perspective on assessment targets) An international GHG emissions calculation and report standard, the GHG Protocol, has three emissions scopes, namely Scope 1 (direct emissions from one's own business), Scope 2 (energy-related indirect emissions in one's own business), and Scope 3 (other indirect emissions). The total of these three scopes is regarded as the emissions from the entire supply chain.[21] Although the water business is also considered from the viewpoint of Scope 1 in the short term, be aware of Scopes 2 and 3 in the long term.
- (Possibility of changes in materials) Mainstream pipe materials could change in the long term. Ductile cast-iron pipes are heavy and require a large amount of energy both for production and transportation. Although resin pipes have already become mainstream in developing nations because of their affordability, they are petrochemical products that could be affected by movements aiming to eliminate fossil fuels. It is desirable, therefore, to monitor technological advancements for reducing the environmental impact and development of devices across the supply chain for both pipe materials.

To simultaneously explore sustainable water supply development and climate change measures, the following conditions are required in addition to above considerations from a long-term perspective.

- Measures to solve problems must be determined, considering direct and indirect benefits for water supply development and climate change measures, when carrying out international cooperation projects.
- Japan must share the experiences of Japanese water suppliers not only in water supply development but also consideration for climate change measures, establish organizational environments, and provide capability improvement such as human resource development to empower water suppliers in developing nations to independently implement measures with long-term synergistic effects.
- Developing nations aspire to establish water facilities for an affordable and stable water supply. These facilities must be able to limit GHG emissions from the viewpoint of synergistic effects with climate change measures. When comparing alternative proposals, proceed with establishing an affordable and stable water supply while considering the need to minimize GHG emissions, taking lifecycle costs (initial investment and maintenance and management costs) and GHG emissions into account.
- Even though water suppliers in developing nations may acknowledge that the use of high-efficient pumps and other equipment, materials with a small environmental impact, etc. will yield significant benefits in the future from the viewpoint of climate change measures, they often hesitate to incur high introduction costs. They are less likely to adopt the above options due to the present funding shortage and many other urgent issues. Some motivations (incentives) are required to introduce measures with major long-term benefits. Effective incentives both for developing and advanced countries could include entrusting projects to private-sector companies, offering payments for contributions to GHG

reduction, and establishing a system where developed countries compensate for the differences between inexpensive ordinary products and high-efficiency products that contribute to GHG reduction through emissions trading.

2－6 Organization of Issues and Lessons that Apply to all Projects

This section summarizes the key points to consider in international cooperation activities in the water supply sector as issues and lessons that apply to all projects.

1) Increasing need to address GHGs when building water supply facilities

Although benefits from expanding the water supply occupy the center of attention when establishing water supply facilities, we can see that the level of awareness about environmental impacts will be also assessed. Those involved in the Japanese water supply industry must also pay attention to how to handle these perspectives in the future.

An international GHGs emissions calculation and report standard, the GHG Protocol, is currently being prepared as an assessment method. Factors such as a possible price rise through carbon pricing must be also considered. This perspective is highly likely to be important in the future, particularly in relation to materials and equipment used in the water business.

2) Accumulation of insights related to the assessment method

We must establish a system for assessing benefits not only to the water business but also to other businesses if the benefits arising from promoting expansion of water supply facilities incur negative effects on the environment.

It is of particular concern that an assessment may indicate an increased environmental impact from the establishment of water supply facilities when comparing the status before and after its implementation (before-after analysis). Although the measures to reduce the environmental impact should be assessed through a with-without analysis, the problem is that “without” conditions are likely to be factitive. Therefore, it is likely that there will be a need to standardize assessment methods, as well as share assessment formats, in the future.

However, target examples where measurements were actually attempted indicate that achieving standardization to a comparable level is challenging, and various obstacles exist. These facts must be examined in the future. Just the scope of this study includes certain examples: the need to use contaminated water sources to secure an adequate water supply; the adoption of water sources that are energy-disadvantageous, because alternative options may not keep pace with population growth or the influx of refugees; and the difficulty in measuring demand due to security reasons in the first place.

3) Tradeoffs between GHG reduction measures and the priority of establishing water supply facilities

Investing in water supply facilities takes a significant amount of capital. In particular, developing nations often experience difficulty in financing, and lack the access to limited resources to link water supply facilities to related projects. Although investment to increase the energy efficiency of water facilities is a win-win project that leads directly to reducing environmental impact, in some cases such efforts may still take a lower priority than building or expanding water facilities. When considering the effects of various measures to reduce environmental impacts, be aware of tradeoffs in the relationship between the investment scale, effects on the water business, and reducing effect of environmental impacts.

Column 1: Definition of non-revenue water rate

The definition of non-revenue water volume is different between Japan and IWA. The non-revenue water volume according to IWA corresponds to the total of effective non-revenue water volume and ineffective water volume in the Water Supply Statistics in Japan. (Refer to the table below.) This definition is often used in developing nations. Some entities regard the non-revenue water rate as nearly equivalent to the water leakage rate, and use the water leakage rate instead of the non-revenue water rate as the numerical assessment index.

Among the project's target countries, Brazil uses two special definitions (IPF and IPM), which differ from both definitions. In either definition, water consumption in favelas (poor communities) are treated as the water volume for social purposes and not counted in non-revenue water volume.

IPF: This is the ratio calculated by subtracting the actual water consumption (when the household water supply meter reading exceeds 10 m^3/month) or 10 m^3 (when the household water supply meter reading is equal to or less than 10 m^3/month) and water consumption for social purposes from the total volume of distributed water, and then dividing it by the total volume of distributed water. This index is same as IWA in that the basis is the billed water volume. However, the billed water volume is different from the actual water consumption when the household water supply meter reading is equal to or less than 10 m^3/month.

IPM: This is the ratio calculated by subtracting the actual water consumption shown by the household water supply meter and water consumption for social purposes from the total volume of distributed water, and then dividing it by the total volume of distributed water. This index is based on water consumption.

When assessing the non-revenue water rate, you must check its definition and calculation method.

Table 20 Definition of Non-Revenue Water Volume According to IWA, Brazil SABESP (IPF) and Japan Water Supply Statistics

<table>
<tr><th></th><th>Item</th><th>Definition according to IWA (NRW)</th><th>Definition according to SABESP (IPF)</th></tr>
<tr><td rowspan="4">Total volume of distributed water</td><td>Volume of billed water</td><td>Volume of revenue water</td><td>Volume of revenue water</td></tr>
<tr><td>Volume of unbilled water (water consumption for social purposes)</td><td rowspan="3">Volume of non-revenue water
Unbilled Authorized Consumption
＋Water Loss</td><td>Water consumption for social purposes</td></tr>
<tr><td>Apparent loss</td><td rowspan="2">Volume of non-revenue water</td></tr>
<tr><td>Net loss (water leakage)</td></tr>
</table>

<table>
<tr><th></th><th>Item</th><th>Definition according to Japan</th></tr>
<tr><td rowspan="3">Total volume of distributed water</td><td rowspan="2">Volume of effective water</td><td>Volume of revenue water</td></tr>
<tr><td>Volume of non-revenue water</td></tr>
<tr><td>Volume of ineffective water</td><td>(Water leakage volume)
(Reduced water supply)</td></tr>
</table>

Column 2: Current efforts related to pipe materials in the context of achieving carbon neutrality

Ductile cast-iron pipe manufacturers have contributed to decarbonization, for example, by extending the lifetime of products to reduce the lifecycle cost, preventing defects such as corrosion to reduce maintenance and management costs and environmental impact, and making pipes quakeproof to prevent damage from disasters and water leakage. In addition, they plan to further reduce CO_2 emissions at each of the production, distribution, construction, and usage stages. They are also reducing weight and shifting the production process to electric furnaces (Kubota Corporation).[22,23]

Polyethylene pipe manufactures have worked on visualizing CO_2 emissions as one of their efforts to achieve carbon neutrality. High-density polyethylene pipes for pressure are registered as a carbon footprint declaration product according to the SuMPO environmental label program.[24] According to one of the manufacturers, Kubota ChemiX, polyethylene pipes emit less CO_2 than metal pipes during production. They also offer excellent corrosion and quake resistance, which in turn reduce the lifecycle costs, and their spread will help to realize a carbon-neutral and resilient society.[25]

A group of vinyl chloride producers announced their view that their products contribute to realizing decarbonization and resource recycling due to characteristics such as the ratio of petroleum-derived materials

in finished products as low as about 40%, high durability, high material recycling rates, and lower CO_2 emissions than other materials during production (Vinyl Environmental Council).[26] They conducted a lifecycle assessment from material procurement through to disposal, with the results showing that CO_2 emissions per meter during the lifecycle of a pipe with a bore of 150 mm are about 20% those of ductile cast-iron pipes (Japan Chemical Industry Association).[27] In July 2022, there was a media report that reassessment of vinyl chloride pipes and joints is gaining momentum as their advantage of lower CO_2 emissions than metal pipes during the production process or construction work has gathered interest (The Chemical Daily, dated on July 12, 2022).

In the domain of plastic production, heat source conversion (ceasing the combustion of off-gases such as methane, making the heat source carbon-neutral, and using off-gases as raw materials for plastic or rubber), material recycling (reducing the ratio of thermal recycling of disposed plastic and engaging in material or chemical recycling), and material conversion (producing chemical products from CO_2 and water with artificial photochemical technology) are under consideration (Resources and Energy Agency).[28]

Chapter 3　Result of the Field Study (in Kigali City, the Republic of Rwanda) and Recommendations

The field study was carried out by Moeko Yoshitomi, a Deputy Director from the Office of Global Health Cooperation, International Affairs Division, Minister's Secretariat, MHLW.

3－1　The Current State and Characteristics of the Water Supply in Kigali City, Rwanda

The Republic of Rwanda is also called the miracle of Africa, the Singapore of Africa, and so on, and it has been recognized as an A-student of African development. After the Rwandan genocide ended in 1994, the country received aid from developed nations, multilateral development banks, and U.N. agencies, and increased investments through the Rwandan diaspora. Then, under the powerful leadership of President Paul Kagame, who places importance on economic diplomacy, the country's economy rapidly developed and its society has been stable since.

The Rwandan government put great effort into improving citizen's access to water and hygiene as a way to address poverty. It eagerly requested Japan, Europe, and the US to support water supply development, developed water supply facilities by installing hand-operated pumps and groundwater pumps, and as a result, access to improved water sources increased. At the same time, however, as Table 21 shows, the water service coverage is still about 80% and the non-revenue water rate is 42% even in Kigali City, which is the capital city. Therefore, there is still a significant need for improvement in the area of water supply. The current state of the water supply is believed to explain why the third frequent cause of infant deaths is diarrhea after pneumonia, and immature birth.

Table 21 State of the Water Supply in Kigali City

Indicator	Value (2023)
Water supplied population*1	1,745,555
Water supplied area*1	26,338 km^2
Water service coverage*2	82.3%
Average water supply quantity	200,908 m^3/day
Water bill paid	35,555,280,825 RWF*3
Water bill charged	36,655,303,151 RWF*3
Non-revenue water rate*4	42.4%

*1 Total population and national land area
*2 Coverage of the at-least-basic water supply service
*3 RWF: Rwandan Franc (1 RWF = 0.12 yen); about 4.4 billion yen (October, 2023)
*4 WASAC (July, 2022-June, 2023)
Source: Information material released by WASAC in 2023

As its nickname the land of a thousand hills suggests, the country's largest geographical characteristic is that most of the land is elevated between 1,000 to 4,500 m above sea level. The whole country is hilly and some areas are quite steep. During the rainy season, this geographical characteristic leads to soil erosion causing water turbidity. Since water sources are located lower than residentials areas, to which water is supplied, energy consumption required to deliver water is as high as about 2 kWh/^{3}. Reduction of energy consumption for non-revenue water is an urgent task. Management of high water pressure in the water distribution network is also important.

In addition to the above, it is said that the river turbidity and water level changes have been significant in recent years because, due to climate change, (1) the rainy-dry season cycle (rainy season in March to May and October to December, and dry season in the remaining months) is changing, and the dry season is becoming longer, and (2) during the rainy season, torrential rain, flooding, and soil erosion occurs in addition to brief but strong rainfall almost every evening.

In Rwanda, the Water and Sanitation Corporation (WASAC) has been carrying out water supply business. WASAC was established under a government order in 2014 and is 100% owned by the government. Meanwhile, cooperatives carry out the water supply business in rural areas to serve dispersed communities. Sometimes, a water cooperative such as the Water Management Committee formed in each village maintains and manages a water supply facility and collects water fees from residents. In September, 2023, WASAC's scope of responsibility widened under a government order, and the corporation became WASAC Group holding two companies that are responsible for construction work (WASAC Development) and maintenance and management work (WASAC Utility), respectively, in water supply and hygiene projects implemented using government budgets. Due to this change, WASAC became a public corporation responsible for overall water hygiene of the country, in both urban and rural areas.

In Rwanda, water consumption is increasing every year due to population growth, economic growth, and urbanization. While the country is working to achieve SDG 6 *Ensure availability and sustainable management of water and sanitation for all*, the national goal of *Make 100% sustainable water access available* needs further effort for the two indicators of (1) the percentage of households that have clean drinking water that can be used when necessary and (2) the percentage of population who are using an improved water source that is within a 30-minute-round-trip away.

In the capital Kigali City, officially, water is supplied throughout the city. The reality is that the household water service coverage is only about 50%. Many residents use public water faucets or water kiosks. One of the contributing factors for this situation is water supply restrictions. The household water supply had problems of poor construction techniques, aged pipelines, difficulty properly managing high water pressure caused by the elevation difference, and difficulty securing and managing the water quantity because pipes were not separated between water supply and distribution and the water distribution area was not divided. These problems became intricately intertwined with each other, leading to frequent water leakage and the inability to secure sufficient water supply quantity, resulting in water supply restrictions. To address this issue, prepaid public water faucets were introduced as a trial. These faucets guaranteed water access 24 hours a day, 365 days a year and helped residents with reduction of time required to purchase water.

In Kigali City, a wide variety of doners have carried out water supply development projects. Table 22 is a summary of recent water supply development projects carried out by the Japanese government. For example, the Master Plan Project of Waterworks Improvement and Maintenance in Kigali that ended in 2021 formulated points of operational improvements required for achieving a better water supply by 2050 and also a facility improvement plan. In order to follow the Kigali City Master Plan 2020 to meet water demand from the projected population of 3.8 million in 2050 and at the same time shift the water supply method to an urban water supply method, which is mainly carried out by delivering water to each household, it is mandatory to strengthen the processing capacity of water purification plants, strengthen the water supply and distribution capabilities, and implement measures to prevent water leakages to enable a water supply 24/7. To meet these requirements, we helped with formulation of the Kigali City Water Supply Master Plan to develop facilities efficiently and effectively from the long-term perspective by providing

Grant Aid for strengthening the water transmission capability between Kigali's largest water purification plant called Nzove Water Purification Plant and Ntora Distribution Reservoir (pipeline update), another Grant Aid for measures to reduce non-revenue water (reconstruction of the water service pipe network to normalize water pressure and reduce water leakage), and a Technical Cooperation Project. This master plan prioritizes lowering of the high non-revenue water rate while there is only a limited number of new water sources, but it has been pointed out no progress has been seen in the non-revenue water reduction measures due to shortages of investments in updating of aging facilities.

Table 22 Recent Water Supply Development Projects in Kigali City Carried Out with Japanese Official Development Assistance

Project	Period	Involved Rwandan agencies	Involved Japanese agencies and companies
Project for Strengthening Nzove-Ntora Principal Water Transmission Pipeline in Kigali City (Grant Aid)	From February, 2019 to August, 2023	Water and Sanitation Corporation (WASAC) and the Ministry of Infrastructure	Consultants: Kokusai Kogyo Co., Ltd., Kyowa Engineering Consultants Co., Ltd., and Yokohama Water Co., Ltd. Construction: Tobishima Corporation
Master Plan Project of Waterworks Improvement and Maintenance in Kigali (Technical Cooperation for Development Planning)	From March, 2019 to June, 2021	Water and Sanitation Corporation (WASAC) and the Ministry of Infrastructure	Nihon Suido Consultants Co., Ltd. and Yachiyo Engineering Co., Ltd.
Project for WASAC Utility Turnaround with KAIZEN Approach (Technical Cooperation)	From March 11, 2022 to March 10, 2027	Water and Sanitation Corporation (WASAC) and the Ministry of Infrastructure (MININFRA)	Nihon Suido Consultants Co., Ltd., Yachiyo Engineering Co., Ltd., and Tokyo Water Co., Ltd.
Project for the Improvement of Water Supply Services in the North-Central Area (Grant Aid)	Exchange of Notes and Grant Agreement from December 6, 2022 to 2026	Water and Sanitation Corporation (WASAC) and the Ministry of Infrastructure	Nihon Suido Consultants Co., Ltd.

Water supply development projects sponsored by other doners are also underway. For example, the Kigali Bulk Water Supply Project, which was completed in 2021, was a PPP project enabled with the assistance of the WB and AfDB. In this project, the existing water supply was reinforced in order to meet the water demand, which was increasing as the population of Kigali City grew. The water supply facility was built in Kanzenze of the Bugesera District in the southeastern part of Kigali on the build-operation-transfer (BOT) base and is now providing 40,000 m^3/day of fresh, clean, and safe water to residents of Kigali City and Bugesera.

3－2　Current State and Characteristics of the Water Supply in Rural Rwanda

In rural Rwanda, people live on the top half of hills. They rely on protected spring water, lakes, wetlands, rivers, and agricultural waterways as the water source for daily use. People, women and children in particular, walk up and down steep hills with over 100 m of height difference as they go back and forth between their house and the water source with water-filled jerrycans on their head and in their hands to

secure water. The water may be contaminated by bacteria due to livestock and livestock feed. Some families boil the water to sterilize it, but the water supply is far from being safe and stable. Meanwhile, maintenance, management, and operation of a water supply facility developed in a development assistance program have been left to residents without sufficient technical transfer, and as a result, a broken hand-operated pump in a well stays broken without part replacement or repair disabling the water supply or the facility operation system, designed to maintain and manage the water supply facility using collected water charges, may not function properly. In some cases, the pipe of a well rusted to affect the water quality. For these reasons, the rate of access to safe water in rural areas remains around 60%.

The Japanese government has been providing technical cooperation to Rwanda with the focus on eastern provinces where the water supply rate is particularly low to enhance the country's ability to operate, maintain, and manage rural water supply facilities, formulate water supply facility expansion and update plans, and manage spring water as a community water source with the goal of strengthening the country's ability to formulate and implement rural water supply services. Table 23 summarizes recent rural water supply development projects carried out in Rwanda by the Japanese government. Note that, in rural Rwanda, the Water Security Action Team of Japan Overseas Cooperation Volunteers is also working on water and hygiene issues including maintenance and management of water supply facilities.

Table 23 Recent Water Supply Development Projects in Rural Rwanda Carried Out with Japanese Official Development Assistance

Project	Period	Involved Rwandan agencies	Involved Japanese agencies and companies
Rural Water Supply Services and Infrastructure Management Development Project (Technical Cooperation)	From October, 2021 to October, 2026	Department of Rural Water and Sanitation Service (RWSS) of the Water and Sanitation Corporation (WASAC)	Kokusai Kogyo Co., Ltd. and Nihon Techno Co., Ltd.
Water and Hygienic Environment Improvement Project in Kirehe District, Eastern Province (Grant Aid in collaboration with an NGO)	From March, 2023 to March, 2024	Kigarama Sector and Nyamugari Sector in Kirehe District, Eastern Province	WaterAid Japan

3－3　Rwandan Water Supply Goal

In 2017, a seven-year national strategy called the National Strategy for Transformation was formulated with the aim to make the country a high-income country. The strategy sets a goal of raising the percentage of the population that uses an improved water source from 87.4% in 2017 to 100% by 2024. It also aims to increase the amount of renewable water resources from 670 m^3/capita/year to 1,000 m^3/capita/year.

The national development strategy called Vision 2050, formulated in December, 2020 to realize economic growth, sets the goal for the percentage of the population using an improved water source to 100% in 2035 and 100% in 2050 while it was 87.4% in 2020. Vision 2050 also defines the drinking water supply index as the percentage of the population with access to an improved water source at their home. The percentage was 9.4% nationwide (39.2% in cities and 2.3% in villages) in 2016-2017 but its 2035 goal is 55% and the 2050 goal is 99%.

3－4　Administrative Agencies Involved in Rwanda Water Supply

(1) Ministry of Infrastructure

The Ministry of Infrastructure (MININFRA) is responsible for policies of Rwandan public facility improvement. In the field of water supply, the ministry formulates water supply policies and provides guidance and monitors WASAC, which is the country's only public water supplier. In 2010, the ministry formulated the national policy and strategy related to water supply titled the National Policy & Strategy for Water Supply and Sanitation Services and noted the importance of improving access to drinking water, decentralization of authority to supply water, water supply operations by a community, payment from water system users, operation of water supply facilities and their accountability, and eco-friendly water source management. As for the urban water supply, the ministry set the goal of increasing the household water supply to provide safer and cheaper water supply services and stated that the rural water supply would require increased public-private sector cooperation to achieve more efficient and effective services.

(2) WASAC

The Water and Sanitation Division of the public corporation called Energy, Water and Sanitation Authority (EWSA), which was carrying out Rwandan water supply operations, became independent in 2014 as WASAC with 100% government funding. WASAC carries out water supply development projects in Rwanda and operates, maintains, and manages water supply facilities. It consists of the head office in the capital Kigali City and 33 regional branches. Branches collect water charges and expand, maintain, and manage water supply and distribution pipes.

(3) Ministry of Finance and Economic Planning

WASAC earns revenue from water charges but the operations are currently sustained by government support. It aims to become financially independent of the government support by revising the water rate, but the water rate cannot be revised without approval of the Rwanda Utility Regulation Authority (RURA). For this reason, WASAC has not been able to operate solely on revenue from water charges. Negotiations with the government on support requests is done with the Ministry of Finance and Economic Planning (MINECONFIN) via MININFRA.

(4) Rwanda Utility Regulation Authority

The Rwanda Utility Regulation Authority (RURA) permits registration of public service providers including water and sewage service providers, electricity companies, and communication companies. Revision of the water rate requires WASAC to submit an application to RURA for a permit.

3－5 Rwanda's Target in Relation to Climate Change Measures

To achieve comprehensive and sustainable development and to become a climate-resilient country with a low-carbon economy, the Rwandan government set a greenhouse gas (GHG) emission reduction target in line with the Paris Agreement and formulated a strategy and action plan for 2030 titled Nationally Determined Contributions (NDC), and submitted both to the secretariat of the United Nations Framework Convention on Climate Change in November, 2015. NDC builds on the 14 action plans provided in the Green Growth and Climate Resilience Strategy 2011-2050 formulated in 2011 to propose climate mitigation and adaptation methods for key sectors and the framework of indicators.

The revised version of the NDC was submitted in May 2020. Rwanda was under lockdown due to the

serious impact of COVID-19, but under such circumstances, Rwanda still managed to review its domestic goals for anti-global warming measures, consolidated actions required to achieve carbon neutrality as Action Plan for Global Warming Countermeasures, and submitted it before any African country. This is because the country had just lost at least 200 people in natural disasters, such as flooding, that were believed to be intensified due to climate change, and the government was driven to make the NDC as ambitious as possible. Rwanda's GHG emissions account only for 0.001% of global emissions, but the government still plans to set a goal of reducing GHG emissions by 8% by 2030 and allocate a 1.1 billion USD budget to achieve this goal.

The National Strategy for Transformation formulated in 2017 emphasizes the environment and climate change as one of the seven cross-sectoral priority areas. It says a mechanism for fighting climate change requires strengthening of cross-sectoral cooperation.

Vision 2050, the national development strategy for economic growth, was formulated in alignment with the Green Growth and Climate Resilience Strategy 2011-2050. It is also incorporated into the Kigali City Master Plan, which includes environmental sustainability and climate resilience.

3－6　Water Supply in Rwanda's Target in Relation to Climate Change Measures

The Green Growth and Climate Resilience Strategy 2011-2050 that the Rwandan government established in the NDC (first version) has 14 items. One of them is *3. Integrated Water Resource Management and Planning*. Specific action plans for this item are as follows:

- Establishment of a weather service for water cooperatives, the agricultural industry, the business industry, and communities (including an early warning system and information network).
- Establishment of a climate center that contributes to observation, monitoring, management, and planning of water resources as well as decision-making regarding water resources.
- Risk assessment of the impact of water and climate and creation of a hazard map as a part of district planning and watershed management.
- Establishment of a framework for water information management that integrates a weather and climate service, agricultural meteorology, water balance monitoring, and demand for groundwater, water supply, and water intake.

3－7　Administrative Agencies Involved in Rwandan Climate Change Measures

(1)　Ministry of Environment

The Ministry of Environment (MOE) bears responsibility for securing appropriate and rational use of water resources, land, and forests to develop a country that expands nature and has climate change resilience while conserving and protecting the environment of Rwanda.

(2)　Rwanda Water Resources Board

In 2000, the Rwandan government established the Rwanda Water Resources Board (RWB) to secure the availability of sufficiently and appropriately managed water resources for sustainable development with the goal of creating a national framework of integrated water resource management. The board takes the initiative in implementing national policies, laws, and strategies that are related to water resources and supervises integrated water resource planning, recovery and erosion control of water catch basins, flood management, and reservoir development. It also supervises water use efficiency and water quality management.

3－8　The Impact of Climate Change Observed in Rwanda and Future Predictions

In accordance with the United Nations Framework Convention on Climate Change, countries must submit to the secretariat the National Communication (NC) that summarizes information including measures and strategies against global warming, future prediction on GHG emissions, effects of climate change and adaptation measures, financial assistance, and technical transfers. In Rwanda, MOE and the Environment Management Authority jointly produced and submitted Third National Communication Under the United Nations Framework Convention on Climate Change (U.N.F.C.C.C) in 2018. Past effects of climate change and future predictions are analyzed in this report.

In Kigali City, the annual mean temperature rose by 2.02ºC over the period between 1971 and 2016. It is predicted that the temperature will rise by 0.21ºC over the period between 2017 to 2050. Annual mean rainfall decreased by 54.32 mm over the period between 1961 and 2016, and it is predicted to decrease by another 0.37 mm over the period between 2017 and 2050. Note that the number of rainy days decreased by 35.8 days on yearly average over the period between 1961 and 2016.

Natural disasters caused by climate change have already been observed including frequent flooding due to heavy downpours (16 times between 1974 and 2018), droughts due to the long dry season becoming longer and the short rainy season arriving later (6 times between 1974 and 2018), and mudslides due to downpours (5 times between 1974 and 2018). These natural disasters are expected to be more frequent, raising concerns for water shortages caused by low rainfall and increase in temperature, poor water quality due to water source pollution, and the risk of destruction of water purification plants and water supply and distribution facilities.

3－9　Climate Change Measures in the Area of Water Supply in Rwanda

Every person we met in Rwanda said something to the effect of "the effect of climate change has become noticeable in how rain falls and around the time when the rainy season starts." We stayed in Rwanda from September 10 to 16, 2023, for the field survey, and during this period, there were a few hours of strong thunderstorms every evening. We heard that the last few years there was brief but strong rainfall every day in the rainy season, and sometimes torrential rain caused flooding and mudslides. Also, Rwanda

traditionally had a short dry season (mid-December to mid-March), long rainy season (mid-March to mid-May), long dry season (mid-May to mid-October), and short rainy season (from mid-October to mid-December), but now, the dry season was becoming longer and the rainy season was starting later and later.

Downpours hit Rwanda from May 2 to 3, 2023. Major flooding and landslides caused devastating damage primarily in northern and western Rwanda. The disaster claimed the lives of 130 people, injured 77, and damaged about 50,000 houses. Highly turbid river water poured into the Nzove water purification plant, which is the latest water purification plant in Kigali City. This caused serious damage to the plant including a landslide near the water intake, breakdown of water facilities, and a 3-day pause in water intake. There were some areas in the city where the landslide led to a strong recommendation for residents to relocate themselves. The Rwandan government re-confirmed that climate change threatens water security.

This series of events made the Rwandan government recognize that reduction of flood damage by torrential rain during the rainy season was the urgent task and have accelerated their efforts to strengthen the country's climate resilience for the past year. Due to such emergencies, these efforts currently focus on climate adaptation strategies. Some of the specific examples of the efforts are as follows:

(1) Develop infrastructure more resilient to climate disasters. The country has in fact started to install water pipes in areas with a lower mudslide risk.
(2) Keep operating infrastructure more resilient to climate disasters. The water safety plan now includes a manual for water supply system operation in times of a disaster.
(3) Form a funding partnership as a financial resource that becomes immediately accessible when a climate disaster occurs.
(4) The country is more motivated to put more efforts into reducing water leakage in order to use limited water resources effectively because climate change has changed the pattern of rainfall to allow rainwater to pour into lower areas of rivers in a short period of time.
(5) The country relies on lowland surface water as a water source but has started to study the groundwater distribution, which is yet to be clarified, and its usage to prepare for changes in the water quantity, water quality, and water retention capabilities.
(6) Introduce climate adaptation strategies in irrigation farming. The country prohibits production of specific crops that retain a lot of water in areas of significant water shortages during the dry season and instructs farmers to produce crops that need a small amount of water.
(7) The country wishes to install more river water level monitoring stations to enhance the ability to monitor weather events and improve the accuracy of weather information, flood information, alerts, and warnings, but has been unable to do so due to financing issues.

As for climate mitigation strategies, based on the fact that (1) water pumping requires a large amount of electricity and (2) insufficient substation capacity and power distribution network maintenance are causing power losses, some government ministries and agencies such as MININFRA recognize the importance of (1) a shift to a different power source and (2) improvement, maintenance, and management of power distribution networks, respectively, to reduce GHG emissions. The country as a whole, however, has somewhat low recognition of these issues and therefore has not promoted work in this area. This seems to be because the government is placing priority on measures against risks of major disasters happening in front of their eyes.

At the same time, the Rwandan government has set a decarbonization goal of *generating 60% of electricity from renewable energy sources by 2030* and is trying to increase the share of hydropower

generation and renewable energy. Increased climate mitigation efforts will contribute to achievement of the national target, and it is hoped that these efforts will be made at a higher pace in the future.

3－10 Rwandan Water Access and Supply Efforts through Integrated Water Resource Management under Climate Change

Integrated water resource management leads to achievement of the Rwandan Green Growth and Climate Resilience Strategy 2011-2050. Some concrete efforts have already been made and are producing significant progress. In April 2022, the Rwandan government released the *Six ways Rwanda is being water wise in the face of climate change*. It is considered a climate adaptation strategy.

(1) Establishment of the Rwanda Water Resources Board

The government recognizes the establishment of the board as demonstration of the importance of water resources in the country's socio-economic transformation and the government commitment to being water wise in the face of climate change.

(2) Creation of the Water Permit System

Rwanda's water resources are under increasing pressure and the Rwandan government needs to know how much water is used, by whom, and where. Once known, the government would be able to manage water use in an efficient and sustainable method by comparing the amount actually used and amount available. The law on water resource use and management gives the Rwanda Water Resources Board tools to collect information required for the optimal management of water resources, and this Water Permit System is treated as one of these tools.

Permission criteria are as follows:

(i) Water resource management

Water resources must be effectively and efficiently managed in order to achieve optimal use of water for national economic growth.

(ii) Fair allocation

Water resource managers must know the amount of water available and the amount of water already in use for water allocation.

(iii) Environmental protection

Water resource managers must confirm that the use of water is efficient and appropriately planned and that pollution is controlled to the minimum level. When allocating water resources to a wide variety of purposes, water resource managers must ensure that the water for environmental flow remains available.

The Water Permit System is a web application that enables water users to apply for a water permit. It can be accessed at www.waterpermit.rwb.rw.

(3) Water storage capacity initiatives

Rwanda has relatively high annual average rainfall of 1,200 mm, and stored rain water is an attractive alternative water source for meeting public need, demand for socio-economic growth, and demand for environmental protection, all of which are rising. The country, however, has a water shortage due to limited water storage capacity. This has led to a study to explore the possibility of expanding the scale of national rainwater storage, and three types of artificial reservoirs were examined (reservoirs for small-scale irrigation, valley reservoirs used to feed livestock with water, and dams used for irrigation and hydropower generation). The country currently has reservoirs in 1,414 locations whose total storage capacity is 131,603 m^3, valley reservoirs in 77 locations with a total storage capacity of over 8 million m^3, and 50 dams

with a total storage capacity of over 75 million m^3. Efforts are underway to scale up the country's water storage capacity and improve rainwater harvesting from residential areas.

(4) The effect of two programs: Water for Growth Rwanda and the IUCN Program

(i) Water for Growth Rwanda (W4GR)

W4GR is a four-year initiative jointly implemented by Rwanda and the Netherlands. With the objective of creating fair, efficient, and environmentally sustainable water resources, this program helped the Rwandan Ministry of Environment implement an integrated approach to water management. In this program, a water catchment plan for 30% of the national land including a strict water allocation plan for various time periods up to 2050. This has enabled Rwanda to accurately grasp how much water it could allocate to irrigation, industry, livestock, water for daily life, and the environment, but the government has suggested the possibility of water shortages and noted the necessity for revising the irrigation master plan and food production policies. In addition to the above, W4GR has helped with establishment of a new water resources board that manages water allocation for the purpose of conflict prevention, water quality improvement, water catchment basin recovery, erosion control, floods, and droughts.

(ii) Integrated Water Resource Management Program by the International Union for Conservation of Nature (IUCN IWRM Program)

The goal of this program is to incorporate sustainable water and wetland management and the mainstream ecosystem approach into the IWRM process in order to achieve reduced poverty, fair development, climate change resilience, and biodiversity conservation. For this purpose, the program proposes six strategic areas of focus ((1) water governance and management, (2) investments in natural water infrastructure, (3) water development, (4) knowledge development and management, (5) cooperative partnership, and (6) climate change, gender, people, and rights).

(5) Improvement of flood management in urban areas

A number of initiatives have been carried out to address flooding in Kigali and other major cities. The Water Resources Board has installed telemetry stations in 15 locations to provide water level data on a real time basis. With these stations, flood hot spots such as drain ditches are monitored, and an early warning system is operated. The board also built water drainage systems in over 40 locations inside Kigali City, identified vulnerable households in flood susceptible areas, and made over 5,000 families in the highest risk areas move to a safer area.

(6) Protection and restoration of urban wetlands

Wetland degradation and pollution greatly affect quality and quantity. A declining capacity of wetlands that provide critical ecosystem services may result in increased flooding and lives lost, damage to infrastructure, reduced productivity, and silting of water bodies.

The Rwandan government prioritized wetland restoration especially in urban areas and produced many concrete results.

- Restoration of important wetland ecosystems.
- Through Rwanda Urban Development Project II (RUDP II), mapping and classification of all wetlands, relocation of industrial complexes from wetlands to more appropriate locations, and restoration of key wetlands.
- Relocation of over 6,000 facilities of commercial activities (parking lots and factories) and family activities from urban wetlands to rehabilitate them.
- Development of a wetland master plan that recommends rehabilitation of 20 km^2, which accounts for

15% of urban wetlands, sustainable use of 29% of wetlands, conservation of 38% of wetlands, and use of the rest for recreational purposes.

In addition to the above, the Rwandan Environment Management Authority created Nyandungu Urban Wetland Eco-Tourism Park with investment from the Rwanda Green Fund, United Nations Environment Programme (UNEP), and the Italian Government. The park stretches over 120 hectares of land in Kigali City and features ornamental ponds, gallery forests, medicinal plant gardens, paved walkways and bike lanes, restaurants, information centers, and so on.

3－11 Climate Change Measures in the Water Supply Area with the Assistance of Foreign Governments, the Multilateral Development Bank, etc.

(1) UNICEF water supply system project by solar power generation

UNICEF worked with World Vision International and WASAC in the Nyagashankara Area in Kirehe District (water supplied population: over 22,000), shifted power generation from diesel to solar power, introduced a compact electric pump system with solar panels, and realized a water supply system that automatically draws water from a well. The pump is powered by electricity generated from 360 solar panels and sends water to water pipes that run 24 miles, 14 storage tanks, 40 public faucets, and domestic water supply pipes for 67 households. The economic cost has halved, and CO_2 emissions have also decreased.

(2) Proposition of the Climate Change Resilient WASH Strategy by UNICEF to support updating of Kigali City Master Plan 2050

Kigali City Master Plan 2050, which was approved in May 2013, is designed to be reviewed regularly in order to respond to changing requests of rapidly developing cities and rapidly increasing citizens. The first review took place in 2020. The master plan includes a wide range of climate change-related plans especially for the current reality of adapting to the temperature and sea level increase. As for water supply, the master plan recommends improvement of water drainage infrastructure to reduce the flood risk and integration of water supply system development with other development projects to optimize the land use.

To respond to increased demand due to rapid urbanization, Kigali City plays an important role in making the master plan a reality by providing developed land and appropriate public infrastructure as well as securing budgets for main roads, public facilities, and key infrastructure. For the infrastructure of Kigali City to meet the criteria of being resilient and sustainable, the city needs to enhance infrastructure resilience and must update its aged existing equipment and network.

Kigali City consulted with international agencies to align the master plan with the activities currently in progress in the city and the ones that are scheduled for the future. To aid the city's effort, UNICEF gave Kigali City detailed input on the method of maintaining, operating, and managing water supply and distribution equipment known as the 'Climate Change Resilient WASH Strategy' to be effective until 2027. At the same time, the WB's currently ongoing project 'Agatare Upgrading Project' considers land use, management, and integration as well as equipment improvement as a means to manage connectivity and rainwater for water resource management.

(3) AfDB's Sustainable Water Supply and Sanitation Program

AfDB has been providing support for expansion of the regional water supply and measures against non-revenue water since January, 2019 with the goal of expanding universal access to a safe and climate change

resilient water supply service in rural Rwanda.

3－12 Future Direction Set through Discussions with the Rwandan Government

Water access supports public health and is essential for sustainable development. Water availability is important for the prosperity of any country. The effect of climate change on water quality, water quantity, and water supply-related facilities may deny securing of access to essential water supply services. Implementation of a climate adaptation strategy related to securing access to water supply services in the future is an urgent task as a part of national security.

Meanwhile, Rwanda's GHG emissions account only for 0.003% of global emissions, and the emission intensity is only 0.05 kg/USD. Much of CO_2 emissions comes from livestock in Rwanda. Emissions from livestock, farming, and land use combined account for 74% of the total emissions. Emissions from energy consumption accounts for 18%, and industrial processes and product use combined account for only 1%. The country, however, committed to shifting to a low carbon society. The government has set the goal of reducing GHG emissions by 8% by 2030. In Rwanda, 56.89% of power is generated from renewable energy sources as of 2015, and 60% is the goal for 2030. To fulfill the commitment to reducing CO_2 emissions, the Rwandan government is aiming at reduction of 1.5 $MtCO_2e$ by prioritizing emissions reduction measures in the fields of energy, industrial processes and product use, waste, and farming, and in the field of energy, by using more solar power generation in hydropower generation, efficient cooking stoves, automobile standards, irrigation, and mini-grids. Achieving this goal requires an effort to reduce CO_2 emissions from power consumption involved in supplying water by using solar power generation to operate water supply facilities. It is however not easy to install solar panels on land with many steep hills. Furthermore, there is an increased number of areas that have become prone to mudslides due to climate change. Under these circumstances, the government must accept that it will become even harder to find an area that may be suitable for solar panel installation near a water supply facility.

Based on this notion, we proposed the following five actions for the Rwandan government to consider prioritizing:

(1) As both a climate mitigation and adaptation strategy, prevent water leakages by stabilizing feed-water pressure

Reduction of water leakage leads to reduction of pump power consumption for taking, directing/redirecting, transmitting, and delivering water as well as reduction of power consumption from the water purification process. It also leads to effective use of water resources to allow preparation for the time of droughts. To achieve this, it is particularly important to control feed-water pressure by repairing water leakages, updating and recreating a water supply and distribution system, maintaining the accuracy of flow rate monitoring, and installing pressure reduction valves while using the Japanese government's Technical Cooperation programs and taking advantage of its experience with creating a block distribution system.

(2) Monitor and manage information about the state of water delivery

Efficient water management and reduction of energy use will be possible by, for example, starting to allocate water to routes that require less energy in the future.

(3) Prepare infrastructure more resilient to climate disasters

Both water supply facilities and solar panels must be installed in places with less risks of climate

disasters.

(4) Operate, maintain, and manage the rural water supply in a sustainable manner

If, for example, a well cannot be used and water must be taken from a river, it is necessary to use a wood stove to boil and purify the polluted water. This requires a large amount of wood and emits CO_2. Repairing the well every time it is broken so that it can be used for a long period of time works as a climate mitigation strategy. In addition, access to safe water improves the health of residents, less use of wood stove reduces respiratory diseases caused by indoor air pollution, and women and children who have to go get water every day can save a lot of time. Furthermore, reduction of wood consumption for firewood leads to protection of forests and prevention of soil erosion or mudslides.

(5) Study the availability of groundwater, which is less affected by climate change

Use of groundwater may not only address water shortages due to climate change but also helps cope with disasters such as flooding or allows water supply for public infrastructure. To be able to use groundwater resources, it is necessary to study and manage underground water sources. In addition, it is necessary to secure funding for creating infrastructure to use groundwater.

Chapter 4 Application of Activities of Domestic Water Suppliers to Support Achievement of Carbon Neutrality in Developing Nations

4－1 Study Policy

We chose domestic water suppliers who were making active carbon neutrality efforts, asked them about their activities that could help developing nations and issues surrounding application of such activities, and organized the obtained information into activity overview, expected effect, matters that could become an issue when applying the activities to a developing nation, measures to adapt the activity to the conditions or situation of a developing nation, and conditions desirable for activity implementation. We also collected information from these water suppliers that could provide useful information for water suppliers in a developing nation to refer to when implementing carbon neutrality measures. The information included their organizational policy and plans as well as points to consider before deciding on implementation. The obtained information was summarized as knowledge to contribute to support of developing nations.

4－2 Study Procedure

From the special article *Decarbonization Efforts in the Water Business* in the April 2023 edition of the Journal of the Japan Water Works Association, we chose the Bureau of Waterworks of the Tokyo Metropolitan Government, Yokohama Waterworks Bureau, and Osaka Water Supply Authority as water suppliers that are making active efforts to achieve carbon neutrality.[29] We asked them to fill out a survey and asked questions based on the answers provided. Table 24 shows the survey items.

Table 24 Survey items

No.	Area	Items
1	Policy	- Reasons for implementing measures to achieve carbon neutrality (e.g., a plan made by a higher-level organization) - Water supplier's policy
2	Details of efforts made	- Efforts that were or are being made to achieve carbon neutrality - Plans for future activities
3	Activities possible to use to assist developing nations	- Activities possible to use to assist developing nations and their reasoning - Conditions and requirements for carrying out activities in developing nations and a method of making such application possible - Particular matters that could become problems
4	Pathway to implementation	- Decision criteria and points of consideration when deciding on implementing the activities - Whether or not the benefits of water development and climate change measures have been sorted out
5	Issues	- Issues in implementation (priority level within the organization, collaboration with other organizations, as well as the budget, human resources, technology, and an evaluation method for the implementation)
6	Planning and progress check	- Overall plan for achieving carbon neutrality and whether or not the progress is checked
7	Information material	- Compilation of experience and findings, guidelines, training material, etc.

4－3　Result of the Water Supplier Survey and Interview

Tables 25, 26, and 27 show the result of the survey and interview of the Bureau of Waterworks of the Tokyo Metropolitan Government, Yokohama Waterworks Bureau, and Osaka Water Supply Authority, respectively. See Section 4-4 for the answers for Question 3.

Table 25 Domestic water supplier's efforts to achieve carbon neutrality (Bureau of Waterworks of the Tokyo Metropolitan Government)

No.	Area	Survey and interview result
1	Reasons for making efforts	- In May, 2019, the Tokyo Metropolitan Government announced it will make *Zero Emission Tokyo* a reality by 2050 to contribute to net zero CO_2 emissions before any other prefectures. - In January, 2021, the Tokyo Metropolitan Government announced that it will halve the GHG emissions inside Tokyo from the 2000 level by 2030 (the *Carbon Half* plan) and will raise the rate of renewable energy use to about 50% of all energy use.
	Bureau's policy	- The bureau does not have its own carbon neutral policy but, as a member of the government, is implementing the Tokyo Metropolitan Government's policy. The bureau has been formulating environmental plans since FY2004 to reduce the environmental impact associated with business activities. - Currently, the bureau is working on reducing CO_2 emissions in line with the Bureau of Waterworks of the Tokyo Metropolitan Government Environmental Five-Year Plan 2020-2024, which was formulated in March, 2020.
2	Efforts made	[Improvement of energy efficiency] - Improvement of the efficiency of continuous power generating equipment - Introduction of a pump system for direct water service - Introduction of energy-saving pump equipment - Upgrading to high-efficiency devices - Implementation of efficient water supply operation [Expansion of introduction of renewable energy] - Introduction of solar power generation facilities - Introduction of micro hydroelectric equipment [Others] - Eco-friendly electricity procurement - Introduction of ZEVs
	Future activities	- Continuing to follow the Bureau of Waterworks of the Tokyo Metropolitan Government Environmental Five-Year Plan 2020-2024, the bureau will implement the energy efficiency and renewable energy measures above at the time of facility maintenance.
4	Criteria and points of consideration for deciding on activity implementation and a summary of data on synergistic effects	- Cost performance is examined based on the facility or pump operation state and future operation plans. - Costs and CO_2 reduction are estimated before facility or pump introduction. - The effect and costs of CO_2 reduction are reported in the form of environment accounting in the annual environmental report.

No.	Area	Survey and interview result
5	Issues in implementation	- It is not easy to secure business viability for expansion of renewable energy generation, and various ways must be explored. - Micro hydroelectric equipment has already been installed where possible, and the next installation timing is when a facility is upgraded again. - The bureau implements environmental measures based on the belief that investment can be recovered. Organizing of thoughts on allowable additional costs will be an issue.
6	Overall plan and progress check	- There is no plan aiming for carbon neutrality, but the Bureau of Waterworks of the Tokyo Metropolitan Government Environmental Five-Year Plan (2020-2024) has been formulated to reduce the environmental impact, and progress is checked every fiscal year.

Table 26 Domestic water supplier's activities to achieve carbon neutrality (Yokohama Waterworks Bureau)

No.	Area	Survey and interview result
1	Reasons for making efforts	- In March, 2011, the Yokohama City Government formulated the Yokohama City Action Plan for Global Warming Countermeasures based on the Act on Promotion of Global Warming Countermeasures. The plan was revised in 2018 and included the goal *Zero Carbon Yokohama* to achieve decarbonization in 2050. - In 2021, the city government implemented the Yokohama City Ordinance on the Promotion of the Formation of a Decarbonized Society. - In February, 2022, the city government announced that it was going to raise its GHG emission reduction target to 50% of the FY2013 level by FY2030, higher than the national government target. It then revised the Yokohama City Action Plan for Global Warming Countermeasures in January, 2023.
	Bureau's policy	- The bureau is implementing environmental and energy measures under the motto of *Eco-Friendly Water Service* based on the Yokohama City Long-Term Water Supply Vision (March, 2016) and the Yokohama City Medium-Term Water Supply Management Plan (FY2020-2023) (March, 2020).
2	Efforts made	- Preferential development of gravity flow type facilities (e.g., water purification plants). Renovation of Kawai Purification Plant to strengthen its processing capacity. Renovation of Nishiya Purification Plant to strengthen its processing capacity. - Introduction of water distribution pump equipment to help with reduction of power consumption (update to the VVVF control type). - Use of solar power generation and micro hydroelectric power generation. - Introduction of high-efficiency lighting such as LEDs and next-generation automobiles (EVs, PHVs, FCVs, and HV).

No.	Area	Survey and interview result
	Future activities	- The bureau will formulate the Yokohama City Medium-Term Water Service Management Plan (FY2024-2027) based on the two city government plans, the Yokohama City Action Plan for Global Warming Countermeasures and the Yokohama City Action Plan for Global Warming Countermeasures (City Hall Edition), to pursue further decarbonization efforts. - The bureau will closely study facilities that can house more solar power generation facilities and formulate an introduction plan. To install such equipment, the bureau will consider using subsidies and grants and adopting a new business method such as PPA. At the same time, the bureau will continue to closely watch the trend of new technology such as equipment downsizing. - The bureau aims to achieve 100% installation of high-efficiency lighting such as LEDs in public facilities by FY2030. - The bureau aims to replace all general public vehicles to next-generation automobiles by FY2030.
4	Criteria and points of consideration for deciding on activity implementation and a summary of data on synergistic effects	- Based on the policy answered in 1 above, the bureau will further proceed with its decarbonization efforts while paying close attention to cost performance, including budgets and the amount of energy reduction, and technical innovation.
5	Issues in implementation	- In the water business, electric equipment such as pumps is used in the process of producing and transmitting water. The electric equipment consumes a lot of electricity and thus produces a lot of GHGs. For this reason, it is necessary to work on reducing the amount of electricity used. - It is necessary to implement decarbonization efforts while paying close attention to cost performance, including budgets and the amount of energy reduction, and technical innovation.
6	Overall plan and progress check	- Decarbonization efforts are made based on the overall plans of the Yokohama City Action Plan for Global Warming Countermeasures and the Yokohama City Action Plan for Global Warming Countermeasures (City Hall Edition). Progress is checked for every area of effort every fiscal year.
7	Information material	- Yokohama City Action Plan for Global Warming Countermeasures https://www.city.yokohama.lg.jp/kurashi/machizukuri-kankyo/ondanka/jikkou/keikaku/plan.html - Yokohama City Action Plan for Global Warming Countermeasures (City Hall Edition) https://www.city.yokohama.lg.jp/kurashi/machizukuri-kankyo/ondanka/jikkou/keikaku/jimujigyou.html

Table 27 Domestic water supplier's activities to achieve carbon neutrality (Osaka Water Supply Authority)

No.	Area	Survey and interview result
1	Reasons for making efforts	- The *Achievement of carbon neutrality by 2050* pledge by the Japanese government in October, 2020
	Bureau's policy	- Among the desirable future states of the authority described in the Osaka Water Supply Authority Future Vision, the authority has chosen reduction of environmental impacts as its contribution to addressing social issues, has set a target of 100% reduction of total GHG emissions from the baseline fiscal year (FY2013) by FY2052, and will make efforts to achieve this goal.
2	Efforts made	- Downsizing of equipment at the time of updating - Introduction of high-efficiency devices - Improvement of water supply and distribution efficiency - Introduction of solar power generation facilities - Leasing land for introduction of micro hydroelectric power generation equipment (July, 2022) - Eco-friendly electricity procurement - EV procurement - Participation in the virtual power plant (VPP) business (trial in 2021 and contract from 2022) - Signing of a Comprehensive Collaboration Agreement in Promoting the Effort to Achieve Carbon Neutrality (onsite PPA contract) with the Kansai Electric Power Company (March 29, 2022) Under the agreement, introduction of solar power generation facilities, storage battery equipment, EVs, discharging and charging equipment, and a power-saving ventilation control service for the Murano Water Purification Plant (full-scale operation began in August, 2023)
	Future activities	- Additional introduction of micro hydroelectric power generation. If the municipal water business becomes integrated, there will be room for considering streamlining of facility layout and renovation. - Additional installation of solar power generation facilities and storage battery and EV charging equipment. There is sufficient space for the installation. - Installation of water filling stations. This is an effort to spread the use of personal reusable bottles, reduce plastic waste, and achieve carbon neutrality for the whole society. It also has the effect of providing a service to residents and preventing heat stroke. Therefore, it not only has PR effects but also leads to achievement of SDGs.
4	Criteria and points of consideration for deciding on activity implementation and a summary of data on synergistic effects	- For the introduction of solar power generation (onsite PPA), the Osaka Water Supply Authority examined its total benefit by also taking into consideration other agreements with the contracting party instead of checking cost performance only for the PPA business. About one year was spent on consideration including discussions with electricity providers. - The authority spent one to two years to consider introduction of micro hydroelectric power generation studying the result of a land usability survey for equipment installation. The authority used to develop installation areas using subsidies, but equipment is often installed on leased land recently. This saves effort including maintenance, but the final decision will be made based on the cost. - The benefits of efforts to achieve carbon neutrality has not been summarized. Since these efforts are not within the authority's main water supply job, the authority believes it is not something to carry out by raising water charges and should be carried out within the extent that does not affect the main job.

No.	Area	Survey and interview result
5	Issues in implementation	- The cost of introducing renewable energy-related equipment can be reduced by using national government subsidies, but the maintenance and management cost is unexpectedly high. This led the authority to find that it would not be able to generate the profit estimated at the time of installation. Additional installation is therefore unrealistic considering the recent financial difficulties. - Introduction of renewable energy generation equipment has no direct impact on the authority's main operation, which is water business (stable supply of safe water that people can trust). Considering future financial difficulties, it is necessary to work on the introduction within the extent not affecting management. This means it will not be possible to implement activities in the same way as before, and the authority therefore will move forward with our activities while examining various strategies such as use of a business model provided by a private sector company like in this case, collaboration with other companies, and use of new technology. - To implement new activities, it is necessary to keep gathering information and trying new activities and widen a network of collaboration to work with companies who seek a win-win relationship.
6	Overall plan and progress check	- The Osaka Water Supply Authority Management Strategy 2020-2029 sets a goal for reducing GHG emissions by 46% by FY2029 (from the FY2013 level). Its progress is checked in the annual report.

4－4 Summary of Study Findings with Regard to Using Water Suppliers' Activities to Support Developing Nations

This section summarizes study findings from two perspectives based on survey and interview results.

(1) Measures considered possible to use to support developing nations and issues when applying these measures

Table 28 shows measures proposed in the study that were considered possible to use to support developing nations. Note that 'Reduce water leakage' mentioned in the interview was added to the responses to the survey carried out prior to the interview.

Table 28 Activities possible to use to assist developing nations

Activity	Type		Description
	Energy saving	Renewable energy	
Introduce pump inverters, introduce energy-saving pump equipment, and re-examine pump operation.	●		Energy consumption control
Update devices to high-efficiency devices and introduce energy-saving equipment.	●		Energy consumption control
Introduce micro hydroelectric power generation equipment.		●	Energy use
Introduce solar power generation facilities.		●	Land use
Introduce storage battery equipment, EVs, and discharging and charging equipment.		●	Shift to low GHG emissions
Develop gravity flow type facilities.	●		Energy use
Downsize equipment when updating.	●		Energy consumption control
Reduce water leakage*1.	●		Energy consumption control

*1 Added from the interview result.

Table 29 shows conditions that allow the use of measures listed above as well as issues and points to

consider when using them.

Table 29 Conditions and points to consider for activity implementation

Activity	Expected effect	Condition	Points to consider and issues
Introduce pump inverters, introduce energy-saving pump equipment, and re-examine pump operation	- Device update and installation of energy-saving pump equipment will reduce power consumption. - Pump operation with an appropriate rotation speed will save energy.	- Pumps currently in use consume a large amount of electricity.	- Advance cost performance examination including a budget, life cycle cost, and energy-saving effect (reduction of power consumption). - Checking of the pump operating point and assessment of energy loss.
Update devices to high-efficiency devices and introduce energy-saving equipment	- Updating devices to energy-saving equipment will reduce power consumption. - Facility power consumption can be reduced by improving energy efficiency of not only water supply equipment but also general devices.	- Devices and equipment currently in use have low energy use efficiency and consume a large amount of electricity.	- Advance cost performance examination including a budget, life cycle cost, and energy-saving effect (reduction of power consumption). - Each activity produces only a minor effect, but building up of activities can produce a substantial effect.
Introduce micro hydroelectric power generation equipment	- Use of potential energy allows water transmission with low energy consumption or generation of energy without GHG emissions. - Power can be generated 24 hours a day.	- There is potential energy and excess pressure that can be used. - An installation area is secured. - There are systems in place to allow the introduction.	- A method of energy use appropriate for the characteristics of each facility (selection of an appropriate energy use such as use of potential energy or power generation using excess pressure). - Securing of a budget and introduction cost. - Cost performance including cost of maintenance and management. - Installation area. - Handling of surplus electricity. - Checking of the requirements for interconnecting the equipment with a distribution system. - Studying of the water hammer effect caused by a generator failure, for example. - Close attention to technical innovation.

Activity	Expected effect	Condition	Points to consider and issues
Introduce solar power generation facilities and storage battery equipment	- Energy can be generated with no GHG emissions.	- There is land for installation. - There are systems in place to allow the introduction.	- Securing of the introduction cost (availability of subsidies). - Cost performance. - Securing of an installation area. - Maintenance and management (labor cost and failure response). - Handling of surplus electricity. - Checking of the requirements for interconnecting the equipment with a distribution system (larger equipment has more demanding requirements, needs additional equipment, etc.). - Measures against wind and flood damage and snowfall. - Close attention to technical innovation. - There will be an equipment disposal cost because it must be disposed of after its service life (17 years in Japan). - Required maintenance such as the frequency of cleaning depends on the weather condition.
Introduce EVs and discharging and charging equipment	- Introduction will save energy.	- Introduction of EVs require a charging environment. - There are systems in place to allow the introduction.	- Securing of introduction costs. - Driving distance and purpose.
Develop gravity flow type facilities	- Creation of an energy efficient water supply system will help with reduction of electricity consumption of pump equipment and other equipment.	- There is an area with topographical and geographical conditions that allow development of a gravity flow type facility.	- Checking of the topographical and geographical conditions of the subject country to decide if a gravity flow type facility can be developed.
Downsize equipment when updating	- Lowering of a processing capacity (water purification capacity) allows downgrading of overall equipment including pumps and the electricity system to save energy.	- Improvement of the revenue water rate has led a lower water purification capacity for the capacity of the facility.	—

Activity	Expected effect	Condition	Points to consider and issues
Reduce water leakage	- Energy can be saved by not producing water that is wasted.	- The water leakage rate is high and there is a large room for improvement.	—

(2) Opinions and information on implementing measures to achieve carbon neutrality

As information that water suppliers in developing nations can refer to when implementing activities to achieve carbon neutrality, Table 30 shows opinions and information from the three domestic water suppliers with regard to formulation of a policy and plan, points to consider and the process toward deciding on implementation of an activity, issues, and the method of progress check. Different water suppliers provided different responses, and the information in the table does not apply to all three water suppliers.

Table 30 Opinions and information on implementing measures to achieve carbon neutrality

Area	Description*
Policy and plan	- The national or prefectural government has a policy or plan (the higher-level organization's plan) on carbon neutrality. - The waterworks bureau has a plan created based on the higher-level organization's plan on carbon neutrality. - The bureau has a policy of setting achievement of carbon neutrality as its important measure.
Opinions on the importance of having a policy or a plan	- Activities to achieve carbon neutrality are not directly linked to the main operation of our water business, which is to deliver safe water, and therefore, implementation is not realistic without a plan, and a plan should be made. - Activities to achieve carbon neutrality are carried out using collected water charges. Therefore, it is necessary to organize our thoughts and move forward with the plan toward the goal. A plan should be made. - Since involved parties in different positions work together in the same direction, a plan should be made. - It is also necessary to advertise the activities to water service users. As a realistic proposal, a plan including costs should be created.
Points to consider before deciding on implementation	- Consideration of conditions unique to each activity. - Consideration of costs of maintenance and management (labor costs, costs of repair when a failure occurs). - Examination of the life cycle cost including removal and disposal costs and the energy-saving effect. - Consideration of cost performance based on the state of facility or pump operation and the future operation plan. - Financing (A budget is allocated to an activity whose investments can be recovered.) - Reduction of introduction costs using subsidies or grants from the national government. - Checking of where the activity is positioned in terms of policy objective, higher-organization's plan, and action plan.
Decision-making process	- Introduction of a device is decided by the person in charge of its operation from the relevant division. - For solar power generation, for example, the general affairs division decides the overall policy and approach. Which facility to put the equipment in or whether or not the activity is cost effective is decided by the division that manages the subject facility. - Plans are decided by the meeting of the executives.

Area	Description*
Summary of benefits (water supply development, climate change measures)	- Costs and CO_2 reduction are estimated before introducing equipment. There are however activities for which estimates cannot be made.
Issues on implementing activities	- Activities to achieve carbon neutrality are costly, and active implementation is unrealistic considering the current financial difficulties. It is necessary to consider what can be done within the extent not affecting the main operation and come up with proposals. - It is not easy to secure business viability for expansion of renewable energy generation, and various ways must be explored. - The waterworks bureau alone cannot halve carbon emissions or achieve carbon neutrality. - It is necessary to implement activities toward a goal, and at the same time, think of what is needed as we go, and move forward while taking into consideration the profitability.
Method of progress check	- Progress is checked every year based on the plan. - The effect and costs are reported in the form of environment accounting in the environmental report. - Progress is checked in the annual report.
Information referred to	- Water utility industry journals, activities implemented by other water suppliers - Information on private sector companies (business methods such as PPA business and ESCO business) - Interviews with pump and device manufacturers (energy saving, new technology, whether or not there are suggestions on improvement) - Information materials from the national government's review committee (to look for programs such as renewable energy programs that can be used) - Manuals on relevant topics published by the Ministry of Land, Infrastructure, Transport and Tourism and the Ministry of the Environment

* This list shows responses from all three water suppliers, and responses do not apply to all three water suppliers.

4－5 Summary

(1) Activities possible to use to support developing nations

Through the survey and interviews, this section has gained an overview of activities implemented by Japanese water suppliers and extracted their effects and issues of implementation. As a result, roughly three types of activities have been identified as activities possible to use to assist developing nations. This section summarizes these activities and considers the possibility of collaboration between these water suppliers and other business fields.

1) Introduction of high-efficiency devices

This activity aims to reduce environmental impacts by updating devices to ones with high energy efficiency. This includes introduction of pump inverters, introduction of energy-saving pump equipment, updating of devices to high-efficiency devices, and introduction of other energy-saving equipment. These high-efficiency devices have already been widely introduced in Japan, and the water suppliers have built up their knowledge about them. In international cooperation, it is considered that Japanese experience that has been built up can be widely applied as is to developing nations and should be introduced actively although there are points to note such as securing of an after-sales service system in the target country.

2) Introduction of renewable energy generation equipment

This is an activity to collect energy by using water facilities. This includes introduction of solar power generation facilities and micro hydroelectric power generation equipment. These types of equipment

produce clear effects, and installation has become easier due to enhancement of recent products. Meanwhile, introduction of renewable energy is not directly connected to water supply system maintenance. Considering funding restrictions, which is significant in developing nations, it is necessary to make adjustments with the target country and see if equipment introduction is so crucial that funds intended for water supply system maintenance must be used.

Consideration of introducing solar power generation is relatively easy due to the maturity of the market, but it is still necessary to study the local situation to see if benefits are commensurate with the funds. Introduction becomes an option if there is abundant excess area, a device maintenance system can be developed, and there is a support program such as the Japanese FIT program. For micro hydroelectric power generation, a water facility having surplus potential energy that can be allocated to power generation is the prerequisite for equipment installation. However, water facilities should be designed efficiently so that such surplus potential energy will not be generated. Therefore, it is necessary to check if the facility is right for equipment introduction.

3) Improvement of energy efficiency for the entire water business

This is an activity designed to reduce losses primarily in water transportation. Since the water business consists of facilities that connect a water source with consumers, improvement of energy efficiency is an effective activity that not only raises operational efficiency of the water business but also directly leads to reduction of GHG emissions. Examples of such an activity include development of gravity flow type facilities, downsizing of equipment at the time of update, and reduction of water leakage.

If implemented, maintenance of a water supply system taking advantage of a gravity flow, including relocation of the water intake to upstream, will produce a significant long-term effect. Note, however, this will be influenced by geographical characteristics. Having an area with topographical and geographical conditions that allow such maintenance is a prerequisite. Implementation of this activity requires coordination with various entities involved in agriculture, hydroelectric power generation, and so on, but it is often the case that there are no systems for such coordination. Many river systems cross a border, and if it is an international river in particular, the power balance between the countries may lead to a political issue. Sufficient preparation and negotiations are thus required. Downsizing of equipment at the time of updating is important in Japan, but in developing nations, supply is not catching up to demand in most cases and there will be only a few cases where equipment downsizing is effective. Reduction of water leakage is not included as an activity choice for achieving carbon neutrality in Japan, but know-how of this area has built up over time. Overseas, there seems to be much room for spreading the notion that water leakage must be reduced in order to decrease GHG emissions by appealing to the target country.

4) Activity implementation through collaboration with other business fields

It has been pointed out that the water business alone cannot halve carbon emissions or achieve carbon neutrality because the GHG emission reduction rate target has been set in expectation of a future change in the breakdown of the amount of power generated by source. Efforts have been made to achieve carbon neutrality also in other business fields such as the sewage business. In the field of sewage, suppression of GHGs produced in sewage and sludge treatment, recovery and reuse of energy from sewage sludge, and reduction of energy involved in aeration have large potential as climate mitigation strategies. For this reason, carbon neutrality will be a closer future if the water and sewage fields jointly formulate a plan.

In our studies carried out in the FY2022 project, we came across efforts by overseas water suppliers to respond to the impact of climate change in the area of water supply. For example, in order to achieve carbon neutrality, a water supplier developed a comprehensive strategy as a water sector strategy involving both the water and sewage business. There was another example in which a water supplier believed that cooperation with a supply chain and collaboration with other sectors, cities, and communities were essential to respond to the impact of climate change. Japanese water suppliers may be able to improve the efficiency of their effort to achieve carbon neutrality by working with other business fields.

(2) Factors to determine implementation of environmental impact reduction measures

This chapter has suggested that Japan has knowledge to contribute to GHG emission reduction through international cooperation in the water supply field. However, there has not been any assistance measure in international cooperation efforts that has environmental impact reduction as its pillar. With the focus on this fact, this section uses comments received during an exchange of opinions in the interview to summarize the current state of activity implementation.

- An activity whose main objective is reduction of environmental impacts is also a measure to enhance energy efficiency. For this reason, environmental impact reduction has been actively incorporated as an important perspective into activities that need investments. *1) Introduction of high-efficiency devices* above is an example of this case.
- *2) Introduction of renewable energy generation equipment* above, which produces only a modest synergistic effect with water business, has been carried out when a situation allows and within the extent that investments do not cause financial burdens.
- Water suppliers, large ones in particular, have been implementing measures to enhance energy efficiency, which in turn enhances operational efficiency. *3) Improvement of energy efficiency for the entire water business* above falls into this category. Note however, their measures are not explained as activities with the objective of implementing environmental impact reduction measures.
- Since water business is carried out using collected water charges, it is not easy to determine how great an investment should be made into environmental impact reduction that is not directly linked to water supply management. Information on investments to achieve decarbonization has not been sorted out.
- Environmental impact reduction measures basically are an effort made by the whole municipality, and there is no sense that the waterworks bureau is leading this effort. The waterworks bureau is doing what it can do such as setting goals and making a plan for the waterworks bureau, but there has not been any scheme to make a joint effort while developing a relationship with a third party.

To recapitulate the water suppliers' policy for reducing environmental impacts listed above, determination of implementation of measures seems to require close attention to not only the effect of environmental impact reduction but also to the scale of an investment and enhancement of water supply efficiency. Figure 1 shows an example of the effect of water supply system development in each measure, relative size of an investment, and its characteristics. It should be noted that the effect of water supply system development, size of an investment required, and the size of the environmental impact reduction effect vary with the condition of the target developing nation (e.g., location, geography, timing of equipment update, and level of facility aging) and the position of the measure may change depending on the local situation.

- A measure with a limited investment that results in water supply efficiency-enhancing effects and

reduction of environmental impacts simultaneously is of course implemented (e.g., improvement of pumping efficiency).

- A measure with a limited investment that results in a modest water supply efficiency-enhancing effects (e.g., solar power generation) is often considered difficult to decide if it should be implemented even though additional costs are required. In this case, the measure can move forward with third party support such as a municipality policy or a subsidy program.
- A measure with a very large investment that results in water supply efficiency-enhancing effects will be implemented continuously within the extent possible in terms of management (e.g., reduction of water leakage). Note that the effect of environmental impact reduction of such activity has not attracted attention in Japan. The relationship between the investment and the effect has not been explained sufficiently either. (Japan has a lower NRW standard than other countries, but what kind of investments made it possible has not been explained much. There has not been much discussion on how to set a target either.)

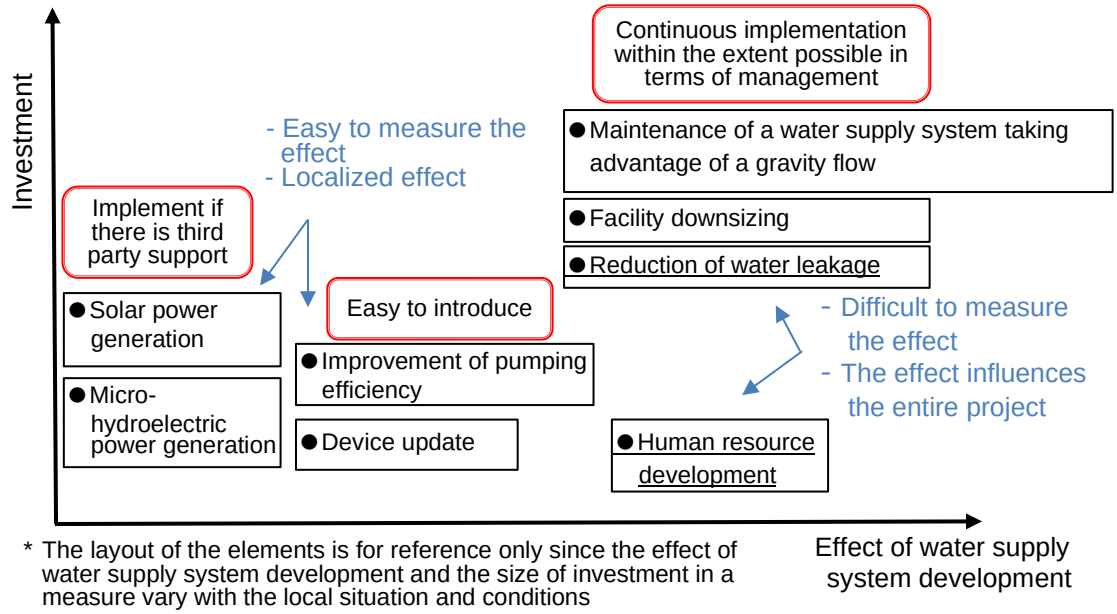


Figure 1 An example of the water supply system development effect, investment, and environmental impact reduction effect in an environmental impact reduction measure

Chapter 5 Innovation Using Products and Technology of Japanese Companies and Information Obtained on Site Visits

5－1 Study Policy

Compiling knowledge on innovation that can be observed in site visits, especially activities using products and technology of Japanese companies, for the time when overseas parties involved in water business come to Japan will increase their chances to be exposed to Japanese products and technology and may also lead to creation of overseas job assignments for Japanese private sector companies who have products or technology that meet the needs of overseas water suppliers. It will also provide a response to their request to see Japanese products and can be used in future JICA training programs to give tours to overseas trainees. The present project summarized information in the following procedure.

- Select companies that provide innovative technology and products based primarily on the FY2021 and FY2022 Research and Examination Report on Expansion of Water Infrastructure Export.
- Use open-source information as supplemental information to learn about water suppliers' technology used in innovation as well as companies with products and technology. Companies willing to expand to the overseas market, such as the ones who provided information material written in English, were preferentially selected.
- Treat water suppliers as tour sites to show how products and technology are used. Use publicly available information material to study about them.
- Ask selected companies if they will accept a site tour for overseas parties involved in the water business.
- If a site visit is possible, collect information on important points to keep in mind (how to hold a tour, when to hold a tour, what to show, maximum capacity, tour length, who to give a tour to, and conditions for accepting a tour such as requests and cautions) and easy-to-understand effects from the climate change perspective (phrases/sentences for PR purposes).
- Try organizing information on whether or not there are tour sites for each type of climate change measure and information on technical fields that Japan has advantages in.
- Based on the inquiry responses, organize items to keep in mind during a site visit.

Table 31 shows information materials referred to for company selection, and Table 32 shows the inquiry details.

Table 31 Information materials referred to for company selection

Information material	Detail	Note
(1) FY2021 and FY2022 Research and Examination Report on Expansion of Water Infrastructure Export (Ministry of Health, Labour and Welfare)[30]	Based on *Chapter 5 Collection, Analysis, and Processing of Information on International Expansion of the Water Supply Business* in the FY2021 report, we classified products and services in the water supply field and organized information on the state of overseas business expansion of key Japanese companies and strengths of individual companies. We also examined the current state of each product and service, their future potential, and the state of competition against overseas private sector companies. Also, based on the FY2022 report *Research and Examination of Overseas Expansion of the Water Business and Methods of Grasping Trends*, we studied orders received by Japanese companies and countries they have expanded their business to in order to consider products and services that Japan has particular advantages in.	Used as the primary information material
(2) Water Supply Technology Promotion Hub Project (Osaka City)[31]	It is a project in which the Osaka Municipality Waterworks Bureau invited water suppliers to showcase their items in the permanent exhibition space designed for introducing equipment, material, and technology that contributes to improvement of the overseas water supply. This space is located in the Interactive Training Center in the bureau. Items are displayed from April, 2023 for three years unless changed. Nine companies were chosen for the product and model division, 12 for poster presentation division, and 5 for the video division.	Used as reference material
(3) Water Supply Equipment Exhibition (Federation of Japan Water Industries, Inc.)[32]	It is an exhibition held by the Federation of Japan Water Industries, Inc. during the general meeting of the Japan Water Works Association.	Used as a reference material

Table 32 Inquiry details

Item	Description
Possibility of accepting a site visit	Whether or not, at the time of the inquiry, a company can agree to give a site visit to water supply relevant parties
If the answer is yes at the time of the inquiry	
PR phrases/sentences	Easy-to-understand effects and sentences/phrases from the climate change perspective for the purpose of promoting the company's technology used in innovation
Tour features	Subject technology used in innovation and the place
Site visit conditions	How to hold a tour, when to hold a tour, tour length, maximum capacity, and who to give a tour to
Tour language	Guide person, technical information material, signboards, etc.
Caution	Requests, caution, etc.
If the answer is no at the time of the inquiry	
(Possible) tour features	Subject technology used in innovation
Possibility of accepting a site tour	Possibility of agreeing to give a future site tour to water supply relevant parties
Reason(s)	Reason(s) why the company cannot give a site tour and conditions to agree to give a site tour
Replacement information material	English technical information materials that can be provided instead of a site visit
Other	Whether or not the company information can be included in inquiry contacts or reports

5－2 Summary of Findings on Site Visits for People from Water Supply Relevant Parties

(1) Products and technologies of companies that can hold site visits and categorization

Table 33 shows companies with innovative technologies or products in the water supply sector identified in this study. The technologies and products section lists innovative technologies that can be viewed as listed in the questionnaire response (partially supplemented with information from published materials).

Regarding whether or not facilities can be visited by water supply relevant parties, companies marked with a ○ that can offer site visits must still be contacted in advance to confirm if a visit can be allowed. Companies marked with a △ responded that they cannot currently provide a site visit but may be able to under certain conditions. Examples of such conditions were delivery destination, consent from clients and original companies, restrictions on what can be viewed, and restrictions on who can participate (likely cannot accept private parties for security reasons) Companies that responded that they were unable to provide site visits gave reasons such as that they did not own the facilities, that there were no facilities in the country that were appropriate for site visits, a shortage of staff, or that they provided such information with a presentation in a trade fair or workshop or by providing technical materials.

Table 33 Companies with innovative technologies or products in the water supply sector identified in this study

Name of company or supplier[*1]	Technology/product[*2]	Site visits by people from overseas associated with water supply[*4]	Material (1) Submitted English PR material on technology[*5]
Aichi Tokei Denki Co., Ltd.	Water meters, smart meter technology and products	○	Yes
Eim Electric Co., Ltd.	High-efficiency submersible pumps	△	
ABE NIKKO KOGYO Co., Ltd.	Prestressed concrete tanks, related technologies	—	Yes
NJS Co., Ltd.	Plant asset management systems	—	Yes
Kankyo Electronics Co., Ltd.	Automatic water quality surveillance systems that use fish (bioassay)	○	Yes
Kyowakiden Industry Co., Ltd.	Machinery, control panels, and water treatment systems for sewerage (purification, industrial wastewater treatment)	○	
Kubota Corporation	Iron water pipes for disaster control measures	○	
Kubota Construction Co., Ltd.	Water pipe laying with shield method	△	Yes
Cosmo Koki Co., Ltd.	Technology and products for installation method with no disruption of water supply	○	
Taisei Kiko Co., Ltd.	Extendable TAI-FLEX pipe, Yano Stopper line stop system, water leakage reinforcement fitting, installation method with no disruption of water supply	○	Yes
Chubu Electric Power Company	Collection and use of water supply data using the remote automatic meter reading system that uses Chubu Electric Power’s smart meter communications network	○	
Tokyo Keiki Inc.	Flowmeters, level gauges, and other measuring devices, current measurement configuration facility	○	

Name of company or supplier*1	Technology/product*2	Site visits by people from overseas associated with water supply*4	Material (1) Submitted English PR material on technology*5
Toshiba Infrastructure Systems & Solutions Corporation	Ozone injection control system that uses fluorescence intensity, coagulant injection control system, water demand forecasting and water supply control and management support system	○	Yes
Toyokeiki Co., Ltd.	Prepaid meters, smart meters (target is of water meter maintenance and management methods, basic knowledge, and production processes)	△	
Nagaoka International Corporation	CHEMILES iron, manganese, ammonia, and arsenic treatment system that uses no chemicals	△	
Niigata Swan Energy Corporation	Demand Response (DR) business (Niigata City)	—	
Nihon Genryo Co., Ltd.	Filtration systems that require no filter media replacement (siphon tank, mobile siphon tank), filter sand production	○	Yes
Hitachi, Ltd.	Maintenance and management system (equipment ledger, inspection management)	△	
Fujitsu Limited	Rate collection with e-money Water management and forecasting system using AI	—	
Fuji Tecom, Inc.	Water leakage detection products and water leakage prevention measures	○	Yes
Fracta Japan	Water pipe deterioration diagnosis technology using AI	○	
Horiba, Ltd.	Measurement and water quality analysis system that is compliant with environmental regulations (target is development and production facility for products such as gas analyzers)	○	
Mitsubishi Chemical Aqua Solutions Co., Ltd.	Decentralized water supply system (groundwater membrane filtration system), compact water treatment system (membrane filtration), water quality analysis inspection station and laboratory	○	
Metawater Co., Ltd.	Mobile ceramic membrane filtration system, ozone equipment	—	Yes
Yokogawa Solution Service Corporation	Production control system (DCS, SCADA)	○	Yes
Water suppliers*3	Drought measures, water leak measures, energy saving, use of closed systems in water purification plants		

*1 Company names are in Japanese alphabetical order
*2 The technologies and products section lists innovative technologies that can be viewed as listed in the questionnaire response and is partially supplemented with information from published materials.
*3 Technologies of water suppliers were taken from published materials.
*4 Regarding site visits for water supply relevant parties ○: Visit possible, △: Visit possible under certain conditions, —: Visit not possible
*5 Regarding English PR materials on technology in the FY2021 or FY2022 Research and Examination Report on Expansion of Water Infrastructure Export: Yes: Submitted; Blank: Not submitted

Table 34 shows a summary by category of climate change measures based on the products and

technologies possessed by companies that responded that they are presently able to provide site visits. For companies with technologies in multiple categories, those companies must be contacted individually to confirm which category applies to the technologies and/or products that can actually be viewed. Information on water suppliers and municipalities in the table was found on websites and in published materials. Regarding reconstruction, we listed suppliers that have published reports or other materials about their experiences of floods or other disasters.

This confirms that there are companies that can hold site visits in multiple climate change measures categories and that we can show information about technologies related to reduction of water leakage and improvement in energy efficiency of the facilities as a whole that can offer the synergistic effects of long-term water supply development and climate change measures as Japan's strengths. Regarding disaster preparedness that is one adaptation measure, experience-based knowledge of measures and technologies may be appealing to water supply relevant parties.

Table 34 Companies that can hold site visits for water supply relevant parties and water suppliers and municipalities carrying out measures by climate change measure category

Large category	Middle category	Small category	Companies that can provide site visits[*1], water suppliers, municipalities, and others carrying out measures[*2]
Climate mitigation strategy	Energy saving	Improvement of pumping efficiency	—
		Creation of a water distribution system that avoids pump use whenever possible (uses gravity flow instead)	(Yokohama Waterworks Bureau)
		Reduction of water leakage	Aichi Tokei Denki Co., Ltd., Cosmo Koki Co., Ltd., Taisei Kiko Co., Ltd., Chubu Electric Power Company, Fuji Tecom, Inc., Fracta Japan
		Improvement in energy efficiency of the facilities as a whole	Tokyo Keiki Inc., Toshiba Infrastructure Systems & Solutions Corporation, Nihon Genryo Co., Ltd., Yokogawa Solution Service Corporation
		Reductions of GHG emissions during production	Kubota Corporation, Mitsubishi Chemical Aqua Solutions Co., Ltd.
	Renewable energy	Generation of renewable energy using the land where a water supply facility is located (solar power, wind power)	—
		Generation of renewable energy using the water supply facility itself (hydropower)	—
		VPP and DR using water supply facilities	—
		Buying and selling of green energy	—
	Environmental preservation	Protection and improvement of function of water conservation forests	(Bureau of Waterworks of the Tokyo Metropolitan Government) (Yokohama Waterworks Bureau)

Large category	Middle category	Small category	Companies that can provide site visits*1, water suppliers, municipalities, and others carrying out measures*2
Adaptation measures	Drought	Securing of a climate change-resistant water source: water storage, use of groundwater, design of a water intake facility	(Water suppliers in Shikoku and Kyushu (drought control measures)), Nihon Genryo Co., Ltd. (emergency water supply during natural disasters), Mitsubishi Chemical Aqua Solutions Co., Ltd.
		Reduction of water leakage	Refer to the reduction in leaks section of mitigation strategies
		Promoting of water-saving	(Kagawa Prefecture), (Tokushima Prefecture), (Ehime Prefecture)
		Reuse of water	(Okazaki City Water and Sewerage Department), (Hanshin Water Supply Authority)
	Downpour	Preparation for climate disasters such as floods (mainstreaming of disaster prevention)	Kubota Corporation, Taisei Kiko Co., Ltd., Tokyo Keiki Inc., Nihon Genryo Co., Ltd., Mitsubishi Chemical Aqua Solutions Co., Ltd.
		Measures for reconstruction after floods and other weather disasters	(Iwaki City Waterworks Bureau, Fukushima Prefecture), (Kazusa Suido Koiki Rengo Kigyodan, Chiba Prefecture)
Measures to train personnel in climate change	Maintenance of water supply projects	Reinforcement of the maintenance and management capabilities of suppliers and personnel training	—
		Long-term support framework (machinery)	Kankyo Electronics Co., Ltd., Horiba, Ltd.
	Climate change measures	Training of personnel with climate action expertise	—

*1 Must call in advance to confirm if a site visit can be held.
*2 Water suppliers and municipalities are shown in brackets. The rationale for measures is based on published materials.
—: Unable to confirm a company that can hold site visits in the current study.

(2) Points to note when holding site visits

As points that should be noted when holding site visits based on the questionnaire results, responses from each company are shown comprehensively in Table 35. Detailed information about individual site visit locations shall be in the materials (not published).

The site visit location was usually the head office or a plant owned by the company, but it was sometimes a water purification plant that uses the company's products or a municipality that holds joint demonstrations. In general, there were no special restrictions on who could participate, provided they were involved in the water business, but some wanted people from a related business field or requested the possibility of turning it into a project. The number of people who could participate was generally around 10 and usually no more than around 20, based on restrictions in venue, number of staff who could provide explanations, and time required. Actual trial of work was limited to small groups.

As for the language used, although all companies replied that they had English materials, it should be noted that roughly half said that site visits would be in Japanese and that those participating would need to arrange for their own interpreter.

Points to note for holding site visits concerned rules and clothing in the plant, the weather factor, period for requesting a visit, and access to site visit areas, for example. These varied by site visit content and should be checked when requesting a visit.

Table 35 Information to note when holding site visits for water supply relevant parties

Item	Description	Responses from each company (listed comprehensively)
Eligible for site visit	Place of site visit	- Head or branch office - Plant - Technological development and training center - Municipalities and others holding joint demonstrations, water purification plants - Facilities receiving delivery
Conditions for site visit	Method	- Explanation in the building or online (video materials, lecture format) - In-plant visit/explanation of production processes, product demonstration, actual equipment - Trying construction work - Viewing products in a showroom - Visit of facilities equipped with the products (outside) - If a water purification plant, request explanation of specifications from customers and see actual equipment - Q&A after site visit
	Implementation period	- Discussed each time - Possible any time - Outside of busy periods (e.g., around December to February)
	Time required	- About 1 to 3 hours (most are about 2 hours) - Around a half day to a full day - Coordinated separately
	Number of people accepted	- Site visits are for about 5 to 10 people, up to about 20 people (most are about 10 people) - Up to 3 people when trying out work, etc.
	Reason for restriction on number of people accepted	- Limited venue capacity. - Limited number of staff who can explain in English. - Due to the amount of time required.
	Eligibility	- People associated with water supply in the water and sewerage field, people with basic knowledge of the water supply sector. - Workers who lay pipes for water or sewerage, various types of irrigation, gas, etc. - People involved in water purification are preferred. - People with knowledge related to prevention of water leakage or to water supply services. - People who can create a project with the company. - Water supply business, operators, various types of manager, and water meter technicians and supervisors. - Likely cannot accept private parties. - Anyone is welcome.
Languages	Staff giving explanations	- Staff assist in English. (Responses: 6/15) - Staff can assist in English but an interpreter may be needed, depending on the timing. (Responses: 1/15) - Japanese only, but a staff member can interpret into English if required. (Responses: 1/15) - Japanese only; visitors must arrange for their own interpreter. (Responses: 7/15) - Explanations are only in Japanese, but presentation and video materials can be provided in English.

Item	Description	Responses from each company (listed comprehensively)
	Technical materials, signboard displays, etc.	- Technical materials can be provided in English. - Catalogs are available in English, Vietnamese, Thai, Indonesian, Malay, Filipino, Cambodian, and Chinese. - Videos, technical materials, product catalogs, and other materials can be provided in English. - Product labels in the showroom are in English. - Technical materials are in English, but signs at the facilities are in Japanese and will be verbally explained in English.
Other important points	Requests and important points	- Wear a helmet, appropriate shoes and clothing, etc. in the plant - No taking photos or videos in the plant. - In site visits of business facilities, visitors must follow the important points for site visits. - Outdoor site visits may depend on the weather. - Must send prospective dates early on (e.g. one month prior, around two weeks, at least a week before). - If coming by public transportation, there are some periods of the day with few buses. - Can come by car or minibus. - Can provide transport to and from the nearest station. - A means of transportation is required as the site is in a rural area. - The location for explanation is different from the site being visited, and visitors must use public transportation or other means to travel between the two places. - Need to note the time required for transport by vehicle from the city (e.g., a few hours, requires one free day) - Need participation information in advance for internal procedure concerning export management (transaction screening). May require advance permission from the Ministry of Economy, Trade and Industry in accordance with list rules of the research institute. - Competitors (Japanese) may not participate.

Chapter 6 Past International Cooperation Efforts in the Water Supply Sector by Other Countries or Development-Related Organizations and Synergistic Effects with Climate Change Measures, etc.

6－1 Study Policy

We used a web search and other methods to obtain information on past unique international cooperation efforts by other countries and development-related organizations on climate change impacts in the water supply sector and social issues. We organized the following information from the perspective of synergistic effects of the efforts: implementing organization, target, description of the efforts, expected effects of the efforts on water supply, climate change measures, social issues, and other factors, and notable characteristics that may be useful information for Japan's international cooperation projects. Table 36 shows a proposal of items for organizing information.

In last year's study, we received the impression that there were no major differences with individual projects related to climate change by water suppliers in other countries and action plans. As such, by focusing on differences in method of approach leading to project implementation, we can collect information on unique projects that are not being carried out in Japan's international cooperation.

Table 36 Proposal of organization of examples of international cooperation efforts in the water supply sector by other countries (development-related organizations) that have synergistic effects

Item	Description
Organization	Name of organization carrying out efforts
Target	Target area, target business
Efforts	Efforts and overview of efforts
Effects	Expected effects on water supply development, climate change measures, and other social issues
Characteristics	Notable characteristics
Material	Name of material or URL

6－2 Examples of Efforts by Other Countries and Relevant Development Organizations

In addition to the projects listed in Table 3-2, projects are categorized from (1) to (8) for each characteristic, including cases of policy setting and tool development, for example.

(1) Setting of non-revenue water management incentives in public-private partnerships

As examples of setting of non-revenue water management incentives in public-private partnerships as a method of approach leading to project implementation, there are projects being carried out in cooperation with the WB and IWA and ADB projects.

Table 37 Setting of non-revenue water management incentives in public-private partnerships (WB, IWA)

Item	Description
Implementing organization	WB, IWA
Target areas	All areas
Target projects	Management of non-revenue water
Efforts	Performance-Based Contracts (PBCs) are applied to public-private partnerships in non-revenue water.

Item	Description
Overview of efforts	● What is PBC? PBC stands for performance-based contract and is a contract whereby payment to the contract company is linked to performance. The contractor takes on some risk, but it provides flexibility and discretionary power for determining the means for achieving results. Through this mutually beneficial relationship, the water supplier can adopt technical expertise and equipment while minimizing risk. Although PBCs must be used carefully in accordance with local conditions, those that are set up properly can provide higher reduction of non-revenue water effects than efforts carried out by individual public utility companies. ● History of use of PBCs for managing non-revenue water The WB Group and the IWA cooperated with the PPIAF to established a global partnership in 2016 to enable countries to improve non-revenue water management through PBCs. Programs for the application of PBCs in management of non-revenue water are aimed at increasing awareness of the non-revenue water problem, identifying good examples, simplifying and streamlining contract preparation, and providing developing nations with assistance in projects. ● Challenges with PBCs and necessary matters In the case of many PBCs, the amount of non-revenue water decreases greatly but rises again after the contract ends. As the party entering the PBC often operates differently from water suppliers in terms of staff, technology, work, incentives, information, and budget, when the PBC ends, that important input may be lost. What is needed is the following: - The suppliers themselves must make major reforms, increase autonomy, and establish internal accountability and incentives - Transfer of technical skills, information, and work to water suppliers - The water supplier management team allocates sufficient funds to sustaining and improving this implementation over the long term. (Most important) Training and performance incentives are used as methods for handling continuity. For many PBCs, training and transfer of knowledge is included in the scope of the work, but training alone does not easily prevent reversion, and it is important to encourage accountability and implement reform that rewards action. Another general strategy is also to finely adjust the non-revenue water management strategy and add incentives to reduce loss (approach the optimal level of non-revenue water), and then to sign performance agreements and extend the duration of the maintenance phase. It is also important to stress the need for maintaining non-revenue water results from PBCs at the sector level. ● Implementation examples In Belize, after signing a concession contract, the service provider is transferred from the public water authority to an authorized private company that continues to improve the scope and quality of service, non-revenue water level, and financial situation. Some public service companies (e.g., Jordan) recreated PBC incentives after the contract period ended, for example by paying bonuses to staff, to maintain or further improve the level of non-revenue water. There is also a need for ongoing technical support through consultants, partnership agreements, or partnerships with business operators.
Expected effects (Development of water supply)	Reduction in costs of operation by reduction of non-revenue water
Expected effects (Climate change measures)	Reduction in energy consumption related to non-revenue water
Notable characteristics	The contractor takes on some risk, but it provides flexibility and discretionary power for determining the means for achieving results. The water supplier can adopt technical expertise and equipment while minimizing risk. However, there is a need for strategic measures for continuity after the end of the contract. There is a need to consider transfer of technology to water suppliers and continuity of incentives for a

Item	Description
	long-term reduction of non-revenue water.
Material	● Explanation and case examples (IWA): PBC cases (Ho Chi Minh, Vietnam; Bahamas; Kuala Lumpur, Malaysia; Bangkok, Thailand), examples of hybrid management and maintenance contract that combines a performance-based maintenance and management contract and the regular design-build style contract (Karnataka, India)[33] ● Manual (WB): The Use of Performance-Based Contracts for Nonrevenue Water Reduction (2018)[34] ● Explanation and collection of cases (PPIAF): PBC case (Pakistan (F-WASA), Jordan, Liberia, Kenya (support for national program to promote use), Tanzania, South Africa)[35] ● Report on use of PBCs as a measure against non-revenue water (PPIAF): Using Performance-Based Contracts to Reduce Non-Revenue Water (2016)[36] ● Bids for PBCs, forms for procurement, etc. (WB)[37]

Table 38 Setting of non-revenue water management incentives in public-private partnerships (ADB)

Item	Description
Implementing organization	ADB
Target areas	All areas
Target projects	Management of non-revenue water
Efforts	Performance-Based Contracts (PBCs) are applied to public-private partnerships in non-revenue water. (Case of Karnataka, India)
Overview of efforts	● Scope of contract Work, equipment, materials, and services will be provided in the following three main phases: - Construction (18 months): Expand network, install bulk meters and customer meters - Preparation phase (3 months): Period for transfer between the Ilkal City Council and the private business operator - Operation and maintenance (48 months): Maintenance, connection management, launching of customer service center, monitoring, fee collection, management of staff, training for Ilkal City Council members to prepare for second transfer to the government Provision of funds (through an ADB loan) to the Karnataka Urban Infrastructure Development and Finance Corporation covers all equipment investment costs. In the preparation phase and the operation and maintenance phase, the private business operator covers all costs for operation and management, excluding power charges borne by the public sector and salaries for city council members. This means that the private business operators must cover these costs before receiving remuneration based on the contract. ● Remuneration for private business operators - Construction phase: Fixed remuneration on a quantity basis and early completion bonus - Operation phase: Fixed remuneration (60%) and performance-based remuneration (40%) ● Performance indicators Indicators measured by independent auditors include continuous supply to 98% of approved connections, reduction in water losses, minimum required water pressure, and customer service targets. Before the project, customer services provided were not adequate—water supply only provided to 66% of connected homes, only for 1-2 hours every 2-3 days in the rainy season and 4-5 days in the dry season, and at extremely low water pressure. Practically speaking, it is impossible to accurately measure the amount of non-revenue water, and most customers did not plan to pay for their water at all. The total number of service connections increased from under 3,000 before the start of the project to over 10,000 as of February 2017, and the

Item	Description
	current fee collection rate is regularly over 70%. ● Contract circumstances A contract was signed with Veolia Eau-Compagnie Générale des Eaux (Bangalore project office) in December 2012. The total contract amount was 273,387,473 pounds (approx. 4.27 million dollars) and included a maximum of 31,649,256 pounds (approx. 490,000 dollars) for maintenance and management expenses for 48 months. ● Lessons learned - To ensure success of adoption, public organizations must implement reforms in systems to modernize the water supply service. To motivate people to pay for water supply service, contractual obligations should include activities to raise awareness among local residents by explaining the reforms that are underway and the necessity of paying for water supply service. Adoption of the latest water management customs can help build a good relationship between water supply service providers and local residents. - Giving penalties if target operating efficiency is not met and bonuses for early completion and saving of usable budget for capital expenditure can boost performance of private business operators. It is important that it is performance-based remuneration based on clear indicators that should be measured, such as reduction of non-revenue water and uninterrupted supply. Depending on the situation, however, it may be necessary to carefully set the allocation of risk to minimize unnecessary risk to the public side and attract the private sector. - Most international companies that have obtained contracts generally mobilize local staff rather than send international experts. While this contributes to local development of expertise in water supply service management, it also reduces the potential benefits of adopting the latest expertise from other countries. - This type of contract increases the likelihood of maximizing the benefits of participation of the private sector when the focus is placed particularly on improving governance, building capacity, and streamlining rates and when linked to technical support to improve urban water supply service policies and the system framework.
Expected effects (Development of water supply)	Reduction of non-revenue water, increase in the number of homes connected to the water supply, increase in fee collection rate
Expected effects (Climate change measures)	Reduction in energy consumption related to non-revenue water, reduction in energy consumption related to methods of obtaining water outside of the water supply service
Notable characteristics	Remuneration is set according to performance in the configuration phase and the operation phase. By improving services, the number of connections increases and the fee collection rate increases.
Material	● 24/7 normalized water supply through innovative public-private partnership[38]

(2) Setting of energy saving incentives in public-private partnerships

An example of setting of energy saving incentives in public-private partnership as a method of approach leading to project implementation is the GIZ project.

Table 39 Setting of energy saving incentives in public-private partnerships (GIZ)

Item	Description
Implementing organization	GIZ
Target areas	Jordan
Target projects	Saving energy in water business
Efforts	Increase incentives for implementing private companies related to projects aimed at increased energy efficiency by using an Energy Performance Contracting (EPC)

Item	Description
	approach.
Overview of efforts	● What is EPC? EPC is a means for carrying out an energy efficiency project that reduces the risks to the facility owner and the energy service company (ESCo) and reduces operating costs, and it refers to the contractual relationship between the ESCo (the private sector) and facility owner (in this case, the Water Authority of Jordan = WAJ). It comprises various types of energy services using energy saving procedures and energy-efficient technology. ● Role of the ESCo and remuneration structure The ESCo provides a wide range of services including identification of projects over a set period, planning, funding, construction and installment, and test run and/or operation and maintenance. Payment to the ESCo is based on the reduction of energy costs achieved through improvement in energy efficiency. EPC includes investment costs (energy improvement measures, investment in equipment such as measuring devices), other costs for operation, maintenance and monitoring, and high project costs such as the costs of raising funds, and the ESCo is responsible for all project costs stipulated in the contract. As compensation, the facility owner pays the ESCo an amount equivalent to the level of energy the ESCo saves every month or once a quarter. Payment is based on a fixed baseline set in the contract that is defined in the initial energy survey process. During the contract period, payment to the ESCo and actual electricity fees must not exceed the energy fees estimated to have accrued without EPC intervention. If the amount saved does not meet that estimate, the ESCo absorbs the difference. Payment is structured so that it does not have any negative financial impacts on the facility owner. Most of the technical, financial, and maintenance-related risks lie with the ESCo. ● Benefits of EPC The aims of EPC are as follows: - Reduce energy consumption and costs as part of a comprehensive energy saving strategy with concrete measures. - Improve the pumps, machinery, and electrical devices of pump facilities - Improvement of operation management and performance monitoring - Provision of excellent repair and maintenance results - Improvement of staff productivity and energy saving capacity - Access to the ESCo funding The ESCo uses the latest optimal technologies available to maximize cost reductions achieved, i.e. maximize benefits, and builds the optimal technical solutions for the individual targets. Normally, in the EPC approach, the amount of cost saved is shared, and so, from the view of both reduction in operational costs due to a decrease in power charges and sharing of a reduction in costs achieved, ESCo maximizes benefits to water suppliers (e.g., ESCo 70%, facility owner 30%). These services are carried out either under the responsibility of the ESCo or by the ESCo for WAJ in a service contract to improve performance, enabling reduction in both operational costs and maintenance costs for the facility owner. ● Various frameworks for EPC projects Not all water pumping infrastructure is well-suited to full-scale contribution from the private sector. Regarding the systematic concepts and operational contracts, GIZ developed and provides a flexible incentive-based framework for the implementation of EPC projects, from full-scale EPC to a contract primarily focused on operational services and to essentially complete ODA funding measures with a private sector service component that primarily improves the sustainability of ODA investments.
Expected effects (Development of water supply)	Reduction in energy cost
Expected effects (Climate change measures)	Reduction in energy usage
Notable	In exchange for contracting parties taking on the risks of all project costs, including

Item	Description
characteristics	capital investment, operations, maintenance, monitoring, and financing, they receive compensation equal to the level of energy saved. A baseline is set, and the amount of compensation increases with the increase in level of energy saved. The water supplier can reduce the costs for adoption of new technology, operation, and maintenance while reducing risk. Regarding energy reduction, use of a performance-based approach offers potential for active involvement by the private sector. Reducing the burden on water suppliers and using the private sector's technologies can achieve effects efficiently. Factors related to the system and operating contract, such as the setting or incentives and continuity, must be thoroughly considered in advance to match the target project.
Material	● Energy performance contracts in the water sector[39]

(3) Setting of incentives for environmental protection activities by for-profit companies

An example of efforts to set incentives for environmental protection activities by for-profit companies when raising funds is the KfW case.

Table 40 Setting of incentives for environmental protection activities by for-profit companies (KfW)

Item	Description
Implementing organization	KfW
Target areas	Germany
Target projects	Greening of the sites of for-profit companies, restoration of ecosystems, use of greywater
Efforts	Environmental protection and climate change mitigation are set as the highest priority in business activities, and funds are raised to benefit the protection of the environment and resources. Within that concept, KfW is carrying out a project with incentives set for the activities of private companies. It is also carrying out a project to use treated wastewater as a water resource for water business.
Overview of efforts	● Positioning of protection of the environment and climate Environmental protection and climate change mitigation are growing in importance in KfW's promotion activities abroad. KfW independently developed its own environmental checklist to assess projects in financial cooperation in 1972, well before environmental protection became an official criterion for ODA. Currently, KfW is one of the largest investors in renewable energy in developing nations. Environmental protection and climate change mitigation will continue to be a top priority in all of KfW's domestic and international project activities. In 2019, KfW made 3.5 billion EUR available for related projects around the world. That accounts for 42% of the total promotion amount and demonstrates KfW's focus on financing measures to address climate change and benefit the protection of the environment and resources. ● Funding nature-based climate change measures by companies The German Federal Ministry for the Environment (BMUV) will support activities such as the creation and restoration of more natural ecosystems on company land, tree planting and improvement of land conditions, outdoor greening, building greening, and precipitation management (e.g., rain water seepage and promotion of use of greywater). This measure contributes in terms of both mitigation and adaptation. BMUV subsidizes up to 50 million EUR a year from action plans related to NbS for climate change measures included in the KfW environmental protection program. For-profit companies can submit applications as of July 15, 2023. Funding is provided through KfW development financing, and companies can receive a 40% to 60% repayment bonus for proving that their measures have been successful, reducing the repayment amount. For-profit companies of which over half are private companies are qualified to apply.

Item	Description
Expected effects (Development of water supply)	Mitigation of water stress
Expected effects (Climate change measures)	Absorption of CO_2, reduction of energy consumption, protection and creation of biodiversity, and reduction of climate-related risks such as drought and flood damage
Notable characteristics	Incentives have been set for companies that will take action for environmental protection and climate change mitigation.
Material	● Positioning of protection of the environment and climate in the KfW[40] ● Sustainability report[41] ● Nature-based climate change measures by companies[42]

(4) Efforts to set climate change strategy and align all activities with the Paris Agreement

As examples of efforts align activities with the Paris Agreement by setting organization-wide climate change strategy targets, there is the AFD case, the FCDO case, and the ADB and other MDBs case.

Table 41 Efforts to align activities with the Paris Agreement (AFD)

Item	Description
Implementing organization	AFD
Target areas	All
Target projects	All
Efforts	- As a strategy related to climate change, the AFD announced in 2017 that it would align all activities with the Paris Agreement. - It established the 2050 Facility dedicated to establishing long-term, low-carbon, and resilient development strategies and committed to dedicating 50% of its annual loan amount to projects that have a direct and beneficial impact on the climate.
Overview of efforts	● Strategy to address climate change The AFD declared four major commitments in its Climate and Development Strategy 2017-2022, and the AFD Group become one of the key international donors of climate funding, for example approving 33.3 billion EUR of financing for the climate since 2017 and 6.9 billion EUR in 2022 in developing nations and in countries outside of France. ● Clarification of efforts against climate change 100% alignment of activities with the Paris Agreement: The AFD assessed work to ensure alignment with decarbonization and resilience trajectories. Efforts include strengthening of mainstreaming of the climate change problem in all sectors and projects and assessment of alignment of projects with the Paris Agreement by an independent sustainability assessment organization. ● Strategy for funding to address climate change - Increase the amount of climate financing: The AFD made significant efforts in mainstreaming the climate change problem in all fields and regions in which it operates and great strides in various fields ranging from energy transition and agriculture and to transportation and infrastructure resilience. - Contribute to the redirection of financial and investment flows: The AFD strengthened strategic dialogue and work with financial institutions and the central bank, increased commissioned financing from partners (Green Climate Fund, Central African Forest Initiative (CAFI), European Commission (EC)), and also increased mobilization of the private sector. This helped direct the flow of funds towards climate change. ● Strategy for policies to address climate change Build solutions together and help establish standards: The AFD shares those efforts from the perspectives of partnership, green finance, and integration of

Item	Description
	financial risk from climate change. In addition, the AFD has acted as chairperson from 2017 and calls on public development banks to strengthen their commitment to tackling climate change, for example through the International Development Finance Club (IDFC) network that contributed approximately 1 trillion USD to green financing over the period from 2017 to 2021 and the Finance in Common initiative.
Expected effects (Development of water supply)	Progress in development of water supply through project implementation.
Expected effects (Climate change measures)	All projects are in alignment with the Paris Agreement and have climate action effects.
Notable characteristics	Declared that it would align all activities with the Paris Agreement. Strengthens mainstreaming of the climate change problem in all sectors and projects and has alignment of projects with the Paris Agreement assessed by an independent sustainability assessment organization.
Material	● Climate and Development Strategy 2017-2022[43] ● Water and Sanitation: Our Commitments in 2022[44]

Table 42 Efforts to align activities with the Paris Agreement (FCDO)

Item	Description
Implementing organization	FCDO: Established through the merger of the Foreign & Commonwealth Office and the Department for International Development in 2022.
Target areas	All
Target projects	All
Efforts	As a strategy related to climate change, the FCDO pledged in 2022 that it would align all ODA with the Paris Agreement and takes measures to ensure all new bilateral aid with the UK would be nature-positive.
Overview of efforts	● Pledge of the UK government In its strategy for international development announced in May 2022, the UK government pledged to “ensure that all new bilateral UK ODA aligns with the Paris Agreement in 2023” and to “build on [their] 2021 commitment to ensure all new UK bilateral aid spending does no harm to nature by taking steps to ensure UK bilateral ODA becomes ‘nature positive,’ aligning with the international goal to halt and reverse biodiversity loss by 2030, and the post 2020 Global Biodiversity Framework, once agreed.” ● FCDO Programme Operating Framework (PrOF) The PrOF has been implemented since April 1, 2021. It outlines the principles for designing and providing high quality programs and shows efforts for the international activities provided by the FCDO. It outlines 10 principles and 29 mandatory rules, and one of the rules concerns climate change. “Rule 5: All new programmes (and projects, aid, and events within those programs) must align with the Paris Agreement – an international treaty on climate change and assess climate and environmental impacts and risks, taking steps to ensure that no environmental harm is done. Any ICF programmes must identify and record ICF spend and results.”
Expected effects (Development of water supply)	Progress in development of water supply through project implementation.
Expected effects (Climate change measures)	All projects are in alignment with the Paris Agreement and have climate action effects.
Notable characteristics	The FCDO created a program operating framework that provides a clear structure for action by policy program teams, enabling them to deliver excellent programs and address priorities through the integration of diplomacy and development programs.
Material	● FCDO Programme Operating Framework: overview[45]

Item	Description
	● International Climate Finance (ICF)[46] ● International aid and development[47]

Table 43 Efforts to align financial flows with the Paris Agreement (ADB and other MDBs)

Item	
Implementing organization	ADB and other MDBs (AfDB, ADB, AIIB, CEB, EBRD, EIB, IDB, IsDB, NDB, and WB Group)
Target areas	All
Target projects	All
Efforts	The organizations announced the principles for aligning financial flows with the goals of the Paris Agreement. These principles act as clear guidelines for constructing new lending operations to meet the goals.
Overview of efforts	● Background leading up to establishment of the principles - In 2017, MDBs pledged to align financial flows with the Paris Agreement goals. - In 2019, MDBs formulated a framework that includes six components (alignment with climate change mitigation goals; adaptation and climate-resilient operations; accelerated contribution to the transition through climate finance; strategy, engagement, and policy development; reporting; align internal activities). - The principles that were announced were the result of five years of work and are intended to secure a consistent and harmonious approach. ● Description of guidelines The guidelines show principles on direct investment lending operations, intermediated financing, general corporate purpose financing, and policy-based lending operations. For each type of operation, items are set for assessing if a loan is aligned with the Paris Agreement and alignment can be checked by answering questions. ● Setting of target deadlines Sovereign (public sector) operations should be fully aligned with the Paris Agreement goals by July 1, 2023, and new non-sovereign (private sector) operations should be 85% aligned by July 1, 2023, and fully aligned by July 1, 2025. ● Activities that are considered to be universally aligned with the Paris Agreement mitigation targets (water supply related) - Water supply systems (e.g., expansion, repair), improvement of water quality, water streamlining (e.g., reduction of non-revenue water, efficient processes in industry), drought management, water management at the basin level - Desalination plants require special assessment. - Power generation by coal and peat are universally considered not aligned.
Expected effects (Development of water supply)	Progress in development of water supply through financed project implementation.
Expected effects (Climate change measures)	All loans are in alignment with the Paris Agreement and all financed projects have climate action effects.
Notable characteristics	Has principles that act as guidelines for aligning all lending operations with the Paris Agreement and the views and items to check are organized.
Material	● ADB press release (June 20, 2023)[48] - Joint MDB Methodological Principles for Assessment of Paris Agreement Alignment-Direct Investment Lending Operations - List of Activities Considered Universally Aligned with the Paris Agreement's Mitigation Goals or Not Aligned with the Mitigation Goals

(5) Intervention in policy and regulations and efforts for behavior change

As an example of intervention in policy and regulations and efforts for behavior change to promote

system-wide changes that have broader effects than a single sector, there is the USAID case.

Table 44 Intervention in policy and regulations and efforts for behavior change (USAID)

Item	Description
Implementing organization	USAID
Target areas	All
Target projects	All
Efforts	- USAID established a 2022-2030 Climate Strategy. It uses a whole-of-Agency approach. - Provides guidance related to climate-resilient, low-emissions water security and sanitation programs. Carries out efforts that focus on policies and regulations, such as updating guidelines, and behavior change.
Overview of efforts	● Whole-of-Agency approach For new climate strategies that will be the guidelines for activities up to 2030, instead of the Climate Change and Development Strategy for 2012 to 2018 that focused on specific climate change mitigation measures and adaptation measures, this is a whole-of-Agency approach that calls for involvement in measures by all parts of USAID. This approach focuses on promoting change throughout the entire complex system that will have a far broader impact than any single sector. It is founded on basic principles incorporated in all plans and activities, such as community-led development, equity and inclusion, private sector involvement, NbS, and evidence, technology and innovation. ● Targets and strategy It sets six ambitious numerical targets for 2030 (mitigation, natural and managed ecosystems, adaptation, finance, country support, and critical populations). To achieve comprehensive targets that advance equitable and ambitious actions to confront the climate crisis, efforts are built along two key strategies. 1. Targeted direct action. USAID will carefully target climate change mitigation and adaptation efforts to the highest priority communities and locations—those with the most urgent needs or most immediate opportunities—to maximize its impact. 2. Systems change. USAID will take a systems approach to long-term, transformative changes to cope with the climate crisis—such as transforming food systems to be more resilient, less wasteful, and less environmentally destructive, or transitioning economic systems to be less carbon-intensive—in ways that are comprehensive, equitable, and locally led. ● Guidance related to climate-resilient, low-emissions water security and sanitation programs The following four key takeaways and related examples are introduced. - Water solutions are climate solutions. Water security and sustainable sanitation services are at the heart of both climate resilience and a net-zero greenhouse gas (GHG) emission future. - Systemic and targeted action is required to achieve climate-resilient water security and sanitation that meet human, economic and ecosystem needs. - To drive action on climate solutions, water security and sanitation programs should include interventions focused on policy and regulation; planning, budgeting and management; data collection and analysis; financing; and behavior change, and draw on key principles. - Practitioners should directly address climate risks to programs and should also use additional recommended practices, including alignment with national climate goals, assessment of potential co-benefits to development outcomes, and adaptive management. ● Important points for activities All activities placed the focus on market signals to change stakeholder behavior. Specifically, interventions included: working with local communities, municipalities, civil society, and the local private sector to strengthen market incentives to recycle and conserve water in the industrial sector; facilitating improved water conservation

Item	Description
	through upgrades in metering that changed consumer practices; and introducing water-efficient irrigation practices that helped to increase yields. ● Example (1): National guidelines on solar-powered water systems in Ethiopia In Ethiopia's dry lowlands, maintaining diesel-powered systems is challenging. For this reason, solar-powered rural water systems have been seen as having potential there to build climate resilience and enhance system uptime. Preliminary analysis suggested that solar pumping in rural Ethiopia could achieve economic advantages over diesel-fueled systems after four years of operation. However, more pilots were needed to justify higher upfront costs. USAID's Lowland WASH activity worked in partnership with the Government of Ethiopia and its One WASH National Program, as well as with academics at Addis Ababa University, to update national technical guidance documents, develop a spreadsheet-based solar pumping design tool, and support programs at vocational training centers for installation and maintenance of solar-powered water systems. ● Example (2): Spurring investments through Peru's PES From the droughts, fires, foods, and landslides, to the loss of more than half of its glaciers over the last 50 years, Peru's long-term water security is precarious. The NIWS project, a joint initiative by USAID and the Government of Canada, promotes investments in NbS to enhance water security. These investments are financed through a variety of sources, including an innovative PES scheme that allows water suppliers to earmark and use a portion of water user tariffs to protect and restore upstream water sources. In 2021, NIWS supported Lima's water supplier in their first investment under the PES scheme to restore an important wetland in the high Andes. NIWS also supported the supplier to design and implement the first PES contract to build a plant nursery, which allowed water suppliers to execute PES funds more efficiently while incentivizing local communities to be good stewards of the land. ● Example (3): Water demand management across users in Lebanon Despite abundant natural water resources, Lebanon is water scarce. A main reason is unsustainable water use that will likely worsen as a result of climate change. In urban areas, water is only available intermittently for just eight hours a day on average. As a result, the USAID Lebanon Water Project worked in partnership with the country's five public water suppliers to improve the management of wastewater systems, enhance operations of water business for enhanced reliability, and promote efficient irrigation.
Expected effects (Development of water supply)	(1) Sustainable water supply through the use of sustainable energy (2) Protection and recovery of water resources and resulting sustainable water supply (3) Sustainable water supply from water saving
Expected effects (Climate change measures)	(1) Reduction in CO_2 emissions through transition to renewable energy (2) Protection of water source forests, protection of water resources (3) Protection of water resources
Notable characteristics	Shows guidelines for incorporating climate change into projects. For example, when adopting a system that only provides returns over a long time span, it shows that there must be policy or regulatory intervention such as revising of technical guidelines in cooperation with the government. Achieving that requires careful building of relationships with water suppliers and relevant organizations in the target country and cooperation with those entities.
Material	● USAID Climate Strategy[49] ● USAID Climate Strategy Resource Hub[50]

(6) Nature-based Solutions

NbS that use nature to solve problems have been gaining interest worldwide in recent years for their inclusiveness—they include diverse measures and concepts from a range of fields—and their ability to provide multiple benefits to resolve more than one problem at once through the use of multiple benefits

from nature.[51] An example of an NbS related to water supply is the AFD case.

Table 45 Example of Nature-based Solutions (AFD)

Item	Description
Implementing organization	AFD
Target areas	Areas where there is water stress from climate change
Target projects	Protection of water resources
Efforts	Uses NbS to protect water resources and improve access to drinking water as a way to combat water stress from climate change.
Overview of efforts	● Example (1): Qixian Wetlands, China (Restoring nature through nature) The Changyuan River wetlands dried up over time due to the effects of climate change, resulting in the degradation of entire ecosystems, and a restoration project was launched in 2015 using NbS. There is a filtering garden using aquatic plants to process urban wastewater and supply the wetlands with water and weeping willows were planted horizontally along the river to strengthen the banks naturally. Through this project, the wetland ecosystem and hydrological functioning have been completely re-built over five years, presenting a model for preserving wetlands around the world. ● Example (2): West Bank of Jordan (An innovation combining water treatment and green energy) In the Tubas area that had a water supply rate of 25% and the only source of water was by truck transport, the Nexus North project, financed by AFD and the EU, is based on an innovative approach combining investment in the water, sanitation and renewable energies sectors. In addition to the extension of drinking water connections to the sanitation network, a renewable energy system (small solar power plants) has been designed to operate in a synchronized way with the drinking water network, whose wells and pumping stations are highly energy-intensive. Large solar panels and wind turbines are being installed near the wastewater treatment plants and water facilities to generate the energy they need to operate. The energy costs will be close to zero. The project has already greatly improved living conditions for residents: 20,000 additional people benefit from a drinking water supply service, and 3,000 people from a sanitation service. In Tubas, there has been a 30-fold reduction in the cost of water consumption. The sanitation works have also had a positive effect on the quality of the natural environment and groundwater resources. ● Example (3): Senegal (Protecting water resources in the pout region) The Pout region, 50 km from Dakar, holds groundwater resources that provide 25% of regional supply. Mining and agriculture irrigation rely heavily on these aquifers, which can barely recharge due to the consequences of climate change. In the latter half of 2021, AFD and the Senegalese Government launched a project to facilitate rainwater infiltration and recovery and reduce water-related natural disasters. The solutions include soil erosion control through reforestation, small rock dams called ‘stone lines’ in which stones are set in a line to slow down runoff and enhance water infiltration, groundwater recharging with the rehabilitation of reservoirs, and farming practices that reduce water consumption.
Expected effects (Development of water supply)	(1) Protection and recovery of water resources (wetlands) (2) Expansion of the area connected to drinking water, improvement in groundwater quality (3) Recharging of groundwater
Expected effects (Climate change measures)	(1) Protection of biodiversity (2) Reduction in CO_2 emissions through the use of renewable energy, effects on the natural environment from sanitation works (3) Reduction in natural disasters related to water
Notable characteristics	Solves problems with methods that use the natural environment and renewable energy to reduce additional energy consumption and CO_2 emissions. The methods that can be applied vary with the conditions of the target area.

Item	Description
Material	● Description of 3 NbS projects[52]

(7) Development of support tools

As an example of development of support tools for incorporating climate change measures into development activities, there is the USAID case.

Table 46 Development of support tool (USAID)

Item	Description
Implementing organization	USAID
Target areas	All
Target projects	All
Efforts	USAID developed tools to support climate risk screening and management in strategy, project and activity design. (Available in English, Spanish, and French)
Overview of efforts	● Objectives of support tools Climate risk management is the process of assessing, addressing, and adaptively managing climate risks that may impact the ability of USAID programs to achieve their objectives. These tools are meant to improve the effectiveness and sustainability of development activities by aiding in assessment and management of climate risk. Each tool helps the user produce the documentation required for mandatory climate change strategies and climate risk management in USAID projects and activities, and Excel templates can be used to record results. The tools are intended to be documents that will be continually edited and updated to incorporate feedback and learning as missions and operating units use them to manage climate risk in strategies, projects, and activities. ● Tools offered There are tools to assess and manage climate risk for designing strategies, projects, and activities, and there are also annexes and matrix templates for each sector. For the water and sanitation sector, it provides examples and questions related to climate risk, adaptive capacity, machinery, and climate risk management options.
Expected effects (Development of water supply)	Increased access to water and sanitation
Expected effects (Climate change measures)	By assessing climate risk, incorporate measures into projects from the perspective of mitigation strategies and adaptation measures.
Expected effects (Other social issues)	By referring to annexes in sectors related to other social issues, measures are incorporated into projects from the perspective of problem solving.
Notable characteristics	Items for assessing climate risk are organized into tables. Specific examples of what should be entered into the spreadsheets are shown as comments on cells, and it is designed so that creating a table stimulates ideal views and thinking to have concerning climate risk. Enables assessment and management of climate risk regardless of the level of knowledge of the person handling design.
Material	● Climate Risk Screening and Management Tools[53], [54]

(8) Use of treated wastewater as the source of drinking water

Examples of efforts to use treated wastewater as the source of drinking water are the KfW case and the ADB case.

Table 47 Use of treated wastewater as the source of drinking water (KfW)

Item	Description
Implementing organization	KfW
Target areas	Area where securing water sources is difficult
Target projects	Drinking water production
Efforts	KfW is carrying out a project to use treated wastewater as a water resource for water business.
Overview of efforts	● Water for the Global South (producing drinking water from treated wastewater) Namibia is the most arid country in Sub-Saharan Africa, and natural water resources are not sufficient to provide the growing population with water supply. At the plant in Windhoek, known as the New Goreangab Water Reclamation Plant, urban wastewater has been treated to create drinking water since 2002 using the latest and proven technologies and is returned to the drinking water supply of the Namibian capital. The plant is the first and one of the few in the world where treated urban wastewater is directly used again for the drinking water supply. The existing plant generates around 20,000 m^3 of drinking water per day from the treated wastewater, amounting to a quarter of reused wastewater in the city's total drinking water consumption volume. With a follow-up project launched in 2022, the capacity of a new plant will be expanded by 10,000 m^3 per day. The new facility is financed by KfW, and the government of Namibia contributes to the agency executing the project, Namibia Water Corporation Ltd (NamWater). In addition, DEG, a wholly owned subsidiary of KfW Group, funded the investment of a private company in the 2010s to treat the wastewater from the northern industrial area of Windhoek. In the long term, this improves the quality of the water coming from the Swakoppoort dam, used for drinking water production.
Expected effects (Development of water supply)	Mitigation of water stress, sustainable water use
Expected effects (Climate change measures)	Adaptation to climate change (drought)
Notable characteristics	In areas with an extreme shortage of natural water resources, there is a real-world example for using treated wastewater as one option for water resources, and private companies are receiving funding to implement such projects.
Material	● Water for the Global South[55]

Table 48 Use of treated wastewater as the source of drinking water (ADB)

Item	Description
Implementing organization	ADB
Target areas	Area where securing water sources is difficult
Target projects	Water production for water use by industries
Efforts	ADB is using treated wastewater as a replacement for fresh water.
Overview of efforts	● Use of treated wastewater as a policy Several states in India, such as Maharashtra, have adopted progressive policies on treated wastewater reuse aimed at reducing demand for scarce freshwater and reducing pollution loads and associated health risks. Some states require industries to use treated wastewater as a replacement for freshwater use. Nationally, India approved a policy on fecal and septage sludge management in 2017.
Expected effects (Development of water supply)	Mitigation of water stress, sustainable water use
Expected effects (Climate change measures)	Adaptation to climate change (drought)

Item	Description
Notable characteristics	In areas that lack water resources, there is an example in which national or local governments have approved the use of treated wastewater as a water resource option.
Material	● Strategy 2030 Water Sector Directional Guide (ADB), Case Highlights 4[56]

Chapter 7 Discussion of How to Further Increase the Effectiveness and Efficiency of International Cooperation

This project, which focuses on the synergistic effects between water supply development effects and climate change measures in international cooperation activities in the water supply sector, is a measure and effort that aids in climate-resilient development, emphasized by AR6. Based on the results of the study and discussion, regarding international cooperation activities in the water supply sector that take into account climate change mitigation measures and adaptation measures related to water supply facilities, we discuss the views that should be incorporated, actual measures for problem-solving based on the needs of countries receiving assistance, and the challenges for continuously implementing more efficient and effective activities.

7－1 Summary of Study Results

Chapter 1 summarized the background and history of the study and shows the objectives of the study and the study policy for this fiscal year.

Chapter 2 attempts to assess the synergistic effects by summarizing the qualitative and quantitative assessments with a focus on the synergistic effects between water supply development effects and climate change measures in international cooperation activities in the water supply sector in international cooperation activities that use Japanese ODA. We also discussed the feasibility of both development of sustainable water supply and climate change measures from a short-term and a long-term perspective. The primary objective of international cooperation in the water supply sector is a stable supply of safe water for everyone. Climate change measures in the water supply sector are implemented based on that understanding, and consideration of how measures aid in the sustainability and resilience of water supply should be considered when implementing them. To achieve that, it is important to qualitatively and quantitatively examine the water supply development effects and climate action effects of measures being carried out and to assess the synergistic effects.

Chapter 3 shows the results of a field survey in Kigali, Rwanda. In Rwanda, efforts are needed to address the large energy consumption used in water distribution as a result of the undulating hilly terrain on high land and the high water pressure in the water service network. In recent years, the impacts of climate change have been causing a longer dry season, frequent torrential rain and floods during the rainy season, and soil erosion. The government of Rwanda is implementing climate change measures centered around adaptation measures as an emergency response and taking efforts to improve water access and supply within climate change through integrated water resource management. As an examination of efforts to prioritize based on considerations of how to secure future access to water supply services and implementation of mitigation strategies in the unique terrain, the government made five proposals: water supply pressure stabilization and water leak measures; monitoring and information management of water distribution situation; development of infrastructure that is resilient in the face of climate disasters; sustainable operation, maintenance, and management of rural water supply; and study on the feasibility of groundwater that is less easily affected by climate change.

Chapter 4 details and summarizes the findings of questionnaires and interviews on the use of support for developing nations in efforts by three suppliers that are actively engaged in efforts to achieve carbon neutrality. The efforts that may be usable in support for developing nations proposed in this study can be

categorized into three groups: installation of high-efficiency devices, installation of renewable energy facilities, and increase in energy efficiency of water business as a whole. The findings suggested the importance of focusing on investment scale and the efficiency-enhancing effects as the water supply in addition to the reduction effect of the environmental impact in judgment components for carrying out measures to reduce the environmental impact. Water suppliers in Japan position reducing environmental impact in plans or policies and search for measures to promote efforts within a harsh economic environment to achieve carbon neutrality, for example by using business models provided by private businesses or cooperating with other suppliers. Those experiences may be a useful reference for developing nations as well.

Chapter 5 discusses Japanese companies with innovative technologies from previous years' reports and questions the possibility of site visits by water supply relevant parties. Innovations using Japanese company's products or technologies contribute to various areas in climate change measures for the water supply sector. In particular, concerning technologies related to the reduction in water leakage and improvement in energy efficiency of the facilities as a whole offer long-term synergistic effects, information can potentially be provided through site visits for water supply relevant parties as Japan's strengths.

Chapter 6 examines examples of efforts by other countries and relevant development organizations that have synergistic effects between water supply development and climate change measures. Continually collection examples of efforts by other countries and relevant development organizations can provide hints that should be incorporated into Japan's international cooperation, such as changes in the circumstances surrounding international cooperation, views, and approach methods.

7－2 Discussion of How to Further Increase the Effectiveness and Efficiency of International Cooperation

Measures and directions are considered from the following six viewpoints.

1) Promoting understanding of global trends in carbon neutrality

While this study summarized the latest trends in carbon neutrality and efforts by other countries, awareness of the goal for carbon neutrality by 2050 is still low in Japan. The synergistic effects between water supply development effects and climate change measures are also not being emphasized.

Sustainable Development Goals Report 2023: Special Edition published in July 2023 assesses and reports on the current state of global water and climate change. It points out that achieving the 1.5°C target requires a massive, prompt, and sustained decrease in GHG emissions in all sectors. In addition, the Water Action Agenda published by the UN Water Conference describes many commitments that have been made to combat the issues surrounding water. As we conduct studies and investigations on qualitative and quantitative assessment of the synergistic effects of water development and climate change measures, it is also important to spread an understanding throughout the water sector in Japan about the great need to balance sustainable water supply development with climate change measures in each project.

2) Positioning disaster control measures to combat storm and flood damage and other disasters as climate change measures (adaptation measures)

Internationally, development of disaster-resilient water supply systems is positioned as a pillar of adaptation measures within climate change measures. As the impacts of climate change become visible, developing nations must simultaneously develop their water supply systems, strengthen their resilience

against disasters, and implement climate change measures. In Japan, meanwhile, water supply systems were rapidly developed and efforts were focused on disaster control measures before climate change measures emerged as an issue; Japan's wealth of experience dealing with disasters such as storm and flood damage has significance today as climate change adaptation measures. In terms of international cooperation as well, the water sector in Japan should share Japan's experiences in disaster control measures to counter disasters such as storm and flood damage as experiences that are closely linked to climate change measures.

In addition, water suppliers in Japan carry out various efforts against climate change, water seepage, torrential rain, and changes in water quality, and quantifying those efforts is effective from a long-term perspective in support for developing nations. For efforts that cannot be carried out through water supply projects alone and require cooperation with sewerage projects and river projects, such as dealing with water seepage during floods and moving water resources upstream to improve energy efficiency and water quality, knowledge should be accumulated as a part of climate change measures.

3) Methods for measuring effects

We evaluated each case and examined whether synergistic effects between water supply development and climate change measures are observed, and we found synergistic effects in many projects. We found that development of the water supply produced not only direct effects, such as improvement in the sanitation environment, but could also reduce energy consumption from means of obtaining water other than the water supply, such as transport.

Measurement of the reduction effect of the environmental impact varied by project, and assessment of the effects of adoption climate change measures may vary with the method. For mitigation strategies, however, we have the methodology of the joint crediting mechanism (JCM) and the clean development mechanism (CDM) as standard assessment methods based on an understanding of the GHG protocol. There have been examples of applying these methods in water business, and that information should be announced to the water supply sector.

Concerning methods for evaluating mitigation strategies, conversion of amount of reduction in power consumption into amount of GHG emissions reduction is often calculated in countries that rely primarily on thermal power generation but rarely in countries whose power supply structure has a high ratio of generation of power sources that do not emit GHGs. As the power consumption reduction effects increase with increasing GHG emissions of the country, it is important to check the power supply structure. In water business, it may be easier to show effects and make comparisons by using GHG emissions per unit water content rather than power consumption per unit water content as an assessment indicator.

In particular, there is a great need for evaluation of NRW measures that require large-scale investment. NRW measures in Japan tend not to have a clear cost-effectiveness perspective or clear target level. Considering how foreign investment from countries like the US evaluate NRW based on investment effect, this type of perspective needs to be studied.

Investment in climate change measures can be seen as a matter of prioritizing more efficient measures with larger effects in an attempt to minimize external diseconomies from GHG emissions. If emissions trading expands in the future, a shift will occur in which reducing GHG emissions becomes an economic benefit, and the cost of climate change measures will no longer be simply an additional cost. Methods for measuring and assessing effects should be updated according to the changing situation.

Meanwhile, there are various effects of adaptation measures and effects as water business, making standardization and comparison by quantitative assessment difficult. Assessment of measures varies with

the characteristics and climate change conditions of each target country. In support for developing nations, it is important to consider measures that offer synergistic effects between water supply development and climate change measures, considering local characteristics and conditions.

4) Examination of water supply development effects, investment scale, and environment impacts

It is difficult to simultaneously achieve reduction of investment scale, water supply development effects, and reduction of environmental impacts, creating a trilemma.

Taking measures such as increasing the water supply area by adding new or extending existing facilities and increase the water supply population result in an increase in GHG emissions, making it difficult to achieve synergistic effects with climate change measures. However, when evaluating the trade-offs, if we compare the current facilities with expanded facilities that have an equivalent GHG emissions rate, we can see how the increase in GHG emissions was reduced, providing incentives for making new facilities or expansions energy efficient.

Water supply facility development that is best for developing nations must provide inexpensive and stable water supply and be able to reduce GHG emissions from the perspective of synergistic effects with climate change measures. When companies are comparing and considering alternatives, they must consider life cycle costs (initial investment and maintenance and management costs) and level of GHG emissions, and carry out development that creates an inexpensive and stable water supply with low GHG emissions.

Because of the current lack of funding and great number of urgent issues, water suppliers in developing nations may hesitate to spend the high adoption costs for using devices like high-efficiency pumps and materials with a low environmental impact, even though these are understood to provide large benefits in the future from the view of climate change measures, and so they tend to be harder to adopt. There must be some incentive for adopting facilities that offer large benefits over the long term. Two effective examples may be commissioning of work to private companies with remuneration based on the amount of contribution to GHGs reduction and building a framework in which developed countries provide support through emissions trading to cover the difference between regular cheaper products and highly efficient ones that help reduce GHGs.

Installation of equipment and technologies for climate change measures in infrastructure facilities is often carried out during the period for updating the facilities, and so there is a need for plans from a long-term perspective based on the period for updating facilities or replacing equipment. Water suppliers in Japan aim to reduce environmental impacts and GHG emissions and carry out plans to replace equipment with models that use energy more efficiently when upgrading aging facilities. Those experiences may be usable in international cooperation as well.

5) Balancing health and environment in integrated water and sewerage efforts

In developing nations where there is a shortage of water supply facilities, sewerage development tends to be postponed in favor of water supply development. Going forward, we need to consider how to balance health and the environment while reducing environmental impacts (GHG emissions) when pursuing water supply development. We tend to focus on the health effects for the water supply and the environmental effects for sewerage. However, improvement of water supply can lead to reductions in environmental impacts and energy consumption through increased water supply efficiency and reduced water leakage. Improvement in sewerage service can lead to disaster prevention effects like a reduction in the impacts of torrential rain that is becoming particularly more frequent with climate change, leading to not only a

reduction in environmental impacts, but also a reduction in impacts on human life and property. It is important to do it as quickly as possible as one unit.

Sewerage also offers great potential for climate change mitigation measures, for example reducing GHGs (especially methane and nitrous oxide) produced in the sewage treatment and sludge treatment processes, collecting and reusing energy from sewage sludge, and reducing energy used in aeration. As such, it is easier to formulate carbon neutrality plans when working on water supply and sewerage service together, and the two should be coordinated when considering concrete measures in the future.

6) Training personnel to have knowledge on both water supply and climate change measures

We need to build the capacity of developing nations to develop their water supply and consider climate change measures at the same time, so that water suppliers in those nations can carry out measures on their own that have long-term synergistic effects. To achieve this, we need support measures to develop capacity, such as sharing of water supply development-related expertise of water suppliers in Japan, sharing of experiences with efforts to achieve carbon neutrality and disaster control measures to combat storm and flood damage, environmental development as an organization, and training of personnel with climate change expertise.

Japan's international cooperation will continue to emphasize human resource development and will continue to implement it as an important measure, leading to self-sustaining development of the water supply in countries receiving assistance within the context of climate change, which is the goal of this project.

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