FROM THE GROUND UP

HOW KHULNA CITY SHIFTED ITS WATER SUPPLY SYSTEM FROM SALINATED, DIMINISHING GROUNDWATER TO SURFACE WATER

JULY 2022

ASIAN DEVELOPMENT BANK

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On the cover: As a result of the ADB-supported Khulna Water Supply Project, Kajol Begum, 29, a resident of a low-income community of Khulna City, received her first metered water connection.

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FOREWORD

by the Asian Development Bank

The Asian Development Bank (ADB) proudly shares its knowledge and experience of tackling a significant challenge facing many developing member countries: groundwater depletion and salinity intrusion.

According to ADB's *Asia Water Development Outlook 2020*, salinity intrusion increased by more than one-third in the region's 50 major rivers between 1990 and 2010. South Asia scores the lowest in the outlook's indices for environmental water security, which includes groundwater assessments. The rapid depletion of aquifers can lead to inequities in water access, land subsidence, and an increase in saltwater intrusion in coastal areas. We see this in Bangladesh and South Asia, but also elsewhere throughout Asia and the Pacific.

Water pollution and excessive groundwater abstraction are widening the supply–demand gaps. Climate change and worsening seasonal storms and droughts are also forcing municipalities and water supply operators to drastically alter their approaches to water source development and service delivery.

Khulna City is a prime case study for understanding the challenges that many municipalities and water service providers confront: increasing demand, diminishing groundwater, and widespread salinity intrusion. Being a coastal city, Khulna is predisposed to high saline levels, but overextraction of groundwater and rising sea levels exacerbate this problem. The Khulna Water Supply Project, supported by ADB and the Japan International Cooperation Agency (JICA), sought to understand how these challenges can be met through comprehensive studies to inform design, institutional development, and major overhauls of water supply infrastructure and service delivery.

The Khulna Water Supply and Sewerage Authority (KWASA) has valuable experience for other municipal and water utility leaders who are seriously considering the transition to conjunctive use. It is a practical presentation of how options were formulated and decisions were made for the design of a first-ever surface water source.

We congratulate the Khulna City Corporation (KCC) and KWASA on the steps taken to make Khulna a more livable city. We are also grateful for the partnership of JICA. ADB is committed to continuing to support KCC and KWASA.

Sincerely,
Kenichi Yokoyama
Director General
South Asia Department
Asian Development Bank

MESSAGE

from the Ministry of Local Government, Rural Development and Co-operatives

The Khulna Water Supply Project was implemented by Khulna Water Supply and Sewerage Authority with the overall cooperation of Khulna City Corporation. The project was cofinanced by the Asian Development Bank (ADB) and the Japan International Cooperation Agency (JICA). The project was successfully completed in 2019, applying modern technology for the transmission of treated water to Khulna City from the surface water treatment plant located 25 kilometers away from the city.

I would like to express my gratitude to the Honorable Prime Minister Sheikh Hasina for the approval of such an important project for Khulna City in the perspective of switching to surface water from groundwater. I would also like to thank ADB and JICA for their support to the project.

I am happy to know that on the basis of the success story of this project, ADB produced this publication titled *From the Ground Up*. I believe it will facilitate the sharing of knowledge and experience as well as disseminate information about the good practices of the project across the region.

I wish for the success of this publication.

Sincerely,
Md. Tazul Islam, MP
Honorable Minister
Ministry of Local Government, Rural Development and Co-operatives
Government of the People's Republic of Bangladesh

MESSAGE
from the Khulna City Corporation

Khulna City is located in the coastal belt of Bangladesh. The city is most vulnerable to climate change. Rivers near Khulna are being gradually affected by salinity intrusion due to sea level rise caused by climate change. The water of the surrounding rivers has no use for domestic purposes. The city had numerous water-related issues, which were the greatest obstacles for development and growth. City groundwater was in crisis from overextraction, vulnerable to saline intrusion, and for having excessive iron in many instances. The surrounding surface water bodies have also been contaminated by solid waste and wastewater.

The Khulna Water Supply Project (KWSP) implemented by the Khulna Water Supply and Sewerage Authority (KWASA) and cofinanced by the Asian Development Bank (ADB) and the Japan International Cooperation Agency (JICA) introduced surface water as the main water source to avoid excessive groundwater abstraction. Considering the salinity issue, Modhumoti River has been considered as the source of water, and the intake is located 58 kilometers northeast of Khulna City. The project has successfully overcome the challenge of constructing a transmission main under the bed of Rupsa River for carrying treated water to Khulna City from the surface water treatment plant constructed on the other bank of the river. After completion of the KWSP, the issue of supplying safe water to the city dwellers has been resolved up to large extent through a significant expansion of piped water service area and improvement of service level as well. The initiative of ADB to publish *From the Ground Up* about the KWSP is appreciable indeed, as this will help share knowledge and lessons regarding the project across regions.

I would like to express my gratitude to the Honorable Prime Minister for approval of such an important project in Khulna City. I would like to thank ADB and JICA for providing support to the KWSP, which helped to improve the basic service like supplying safe water to the residents of the city. I would also like to thank the Local Government Division for steering the project and KWASA for implementing the KWSP.

Finally, I would like to mention that the Khulna City Corporation provided all-out support to implement the KWSP and would continue this support for the further improvement of the water supply and sanitation systems in Khulna City.

Sincerely,
Talukder Abdul Khaleque
Mayor
Khulna City Corporation

MESSAGE

from the Khulna Water Supply and Sewerage Authority

Khulna is the third-largest city in Bangladesh, located in the southwestern part of the country along the Rupsa and Bhairab rivers. The city's water supply system completely relied on groundwater, which was insufficient to meet demands and was developed in an unplanned way. The rivers surrounding the city are not freshwater and are at risk of increasing salinity due to climate change. Water distribution infrastructure was old and poorly maintained and did not keep pace with the rapid urban growth. The water tariff was a flat rate for each property connection irrespective of water use. The piped water supply coverage was less than 20% and a daily average of 5.3 hours. Nonrevenue water was as high as 36%.

To address the challenges, the Khulna Water Supply Project (KWSP) was implemented by the Khulna Water Supply and Sewerage Authority (KWASA) in collaboration with the Japan International Cooperation Agency (JICA) and the Asian Development Bank (ADB). The project prioritized the development of a surface water source and construction of distribution infrastructure, and improved the system's performance efficiency. ADB also supported the institutional development of KWASA.

The project was completed in June 2019 and brought a paradigm shift: from groundwater to surface water source; from unplanned distribution infrastructure to a well-designed distribution system, metered property connections; and from manual financial management system to program-based financial system. Piped water service coverage is 65% with 24-hour supply. Nonrevenue water is less than 20%. This significant transformation was made possible by the excellent support and coordination among the Local Government Division, KWASA, Khulna City Corporation, and development partners. It is a praiseworthy initiative of ADB to create this publication, *From the Ground Up*, to record the achievements of the project and to share the knowledge and lessons across the country and abroad.

I would like to express my gratitude to the Honorable Prime Minister for approving the project to improve this basic service for Khulna City population. I would like to thank the Local Government Division for sponsoring the project and Khulna City Corporation for extending all-out support for implementing the project. I also thank ADB and JICA for their assistance. Finally, I hope the development partners will continue to support the water supply and sewerage systems in Khulna City.

Sincerely,
Mohamed Abdullah
Managing Director
Khulna Water Supply and Sewerage Authority

ACKNOWLEDGMENTS

The development of this publication was led by Jaemin Nam, senior urban development specialist, South Asia Urban and Water Division (SAUW), South Asia Department (SARD) with the overall guidance and support of Norio Saito, director, SAUW, SARD.

Masayuki Tachiiri, currently the director of the Strategy, Policy, and Business Process Division of ADB's Strategy, Policy, and Partnerships Department, was the mission leader during the project preparation, overseeing the design and approval of the Khulna Water Supply Project (KWSP). ADB Infrastructure Specialist Elma Morsheda led the project team through much of the implementation stages of KWSP, along with former ADB Senior Urban Project Officer Rafiqul Islam, who was part of ADB's administration team for 2 years of the project's implementation. Tachiiri, Morsheda, and Islam were instrumental in providing substantial background.

ADB is especially grateful to Khulna City Corporation Mayor Talukder Abdul Khaleque for giving generously of his time for online and in-person interviews.

The long-serving staff of Khulna Water Supply and Sewerage Authority (KWASA) participated in informative and candid interviews to explain their experience of designing and implementing the KWSP. ADB is especially grateful for the time and attention given by Mohamed Abdullah, KWASA managing director; Kamaluddin Ahmed, KWSP project director and the current KWASA deputy managing director; and Salim Ahmed Khan, KWSP project manager and the current project director of Khulna Sewerage System Development Project. Together they reviewed this publication multiple times and provided support for the editorial team visiting the project sites. ADB is also grateful to Sudhir Kumar Ghosh, KWSP project management consultant and the former chief engineer of the Department of Public Health Engineering.

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The editorial team was led by Melissa Howell Alipalo (researcher, writer, and editorial director) and supported by Mohammad Rakibul Hasan (photographer) and Fabeha Monir (national editorial support and author of impact stories). All photographs, unless otherwise credited, were taken by Hasan. They are especially indebted to the KWASA staff and beneficiaries who shared their struggles with securing water for their household needs before the KWSP. The publication was edited by Jess Macasaet, proofread by Lawrence Casiraya, page proof checked by Marjorie Celis, and typeset by Alvin Tubio. The ADB Department of Communications provided valuable guidance.

ABBREVIATIONS

ADB	Asian Development Bank
CBP	corporate business plan
DMA	district metered area
JICA	Japan International Cooperation Agency
KCC	Khulna City Corporation
KWASA	Khulna Water Supply and Sewerage Authority
KWSP	Khulna Water Supply Project
NGO	nongovernment organization
O&M	operation and maintenance
TA	technical assistance
WTP	water treatment plant
WUG	water user group

WEIGHTS AND MEASURES

km	kilometer
km^2	square kilometer
kVA	kilovolt-ampere
kW	kilowatt
lpcd	liter per capita per day
m	meter
m^3	cubic meter
mg/L	milligram per liter

EXECUTIVE SUMMARY

In coastal Southwest Bangladesh, Khulna is the country's third-largest city and economy. Its official territory is about 46 square kilometers with an estimated 2020 population of 1.5 million people in the larger metropolitan area. The government's 8th Five Year Plan (2021–2025) indicates that poverty in the larger administrative district of Khulna had seen declines, from 45.1% in 2000 to 27.7% in 2016, before stagnating. However, Khulna City proliferates with slums, mainly on the periphery of the city center.

In the past, all households in Khulna City relied entirely on groundwater resources for their daily needs. Only less than 20% of the city's population had access to piped water supplies from the official municipal service (also from groundwater source) and for 5.3 hours per day. Households (primarily women) spent an average of 90 minutes every day fetching water, with poorer households spending as much as 120 minutes. A significant factor of the city's poor water supply service levels was the age and lack of maintenance on the infrastructure. As a result, at least 36% of the system's water was lost in distribution, about 20,940 cubic meters per day (m^3/day).

The government and the Asian Development Bank (ADB) knew that transforming Khulna's water supply system would require significant investments and institutional change. In March 2008, the government established the Khulna Water Supply and Sewerage Authority (KWASA) to take over the water supply and sewerage responsibilities from the Khulna City Corporation (KCC).

ADB has supported KWASA since its first year of operation through a series of technical assistance (TA) projects to develop its institutional capacity and plan for significant capital investments. In addition, in November 2009, ADB and the Japan International Cooperation Agency (JICA) began supporting KWASA in preparing a project proposal to rebuild Khulna's water supply system with a safe, sustainable water source.

Core Development Challenge

Khulna City was facing three significant water supply challenges. Ultimately, it needed to increase water production to meet current and future demand while reducing groundwater extraction and avoiding the high saline levels in the water sources.

Groundwater extraction. In 2010, Khulna City was extracting an estimated 119,100 cubic meters (m^3) of groundwater daily, more than double the environmentally sustainable limit of 50,000 m^3/day. It was estimated that the city would need to produce an additional 100,000 m^3/day of water from the third, deep, lower-saline aquifer level or develop a new source from surface water to meet current and future demand.

Khulna City, Bangladesh

Source: Asian Development Bank.

Salinity. Finding a surface water source within acceptable quality standards—especially in terms of saline levels—would be a challenge. Saline is a natural characteristic of groundwater and surface water in Khulna City. All the rivers surrounding Khulna City are tidal, and the low-lying swamps and marshes in the city's northwest are a prominent topographic feature. Increasing sea levels is likely to exacerbate the salinity levels in Khulna's rivers, groundwater, and soil.

Finding suitable water. The most crucial step in transforming Khulna's water supply system was to find a safe, sustainable water source to replace and reduce groundwater supplies. Multiple studies over the years have shown that Khulna's groundwater is not expected to satisfy future demand. Furthermore, any viable surface water source would likely be far from the city center because river water surrounding the city tests too high for saline and other high mineralization and turbidity levels for most of the year. The most suitable surface water source was 58 kilometers northeast of Khulna City and did not require costly desalination technologies that closer sources would have required.

The Project: From Groundwater Dependence to Conjunctive Use

With a new surface water source identified, Khulna City needed an overhaul of the entire water supply system—surface water intake facility, transmission main, surface water treatment plant, distribution network, and metered connections—as well as necessary auxiliary assets (such as pumping stations, overhead reservoirs, etc.) and the management system for modern operations of a service provider. The staff also needed training in technical, business, and administrative areas.

JICA provided financing and project administration support for constructing the "upstream" infrastructure: surface water intake facility, raw water transmission main, and surface water treatment plant with impounding reservoir. ADB's financing supported the establishment of the "downstream" infrastructure focusing on a distribution system: clear water transmission main for conveying the treated surface water to distribution reservoirs, overhead tanks, new and rehabilitated piped networks, pumps, valves, and other equipment. ADB also financed installing a supervisory control and data acquisition (SCADA) system and other technologies to enable a smart water management system.

Results: Meeting or Exceeding Targets

As a result of the Khulna Water Supply Project (KWSP), Khulna City is closer to meeting its 2025 demand of around 200,000 m^3/day, having increased production and supplies from 119,100 m^3/day in 2010 before the project to 160,000 m^3/day in piped water supply (110,000 m^3/day from treated surface water and a maximum withdrawal of 50,000 m^3/day from groundwater).

Expanded coverage. The KWSP improved household connection coverage from less than 20% of the population before the project to 65% after the project. Another 26.5% of households, which did not gain access to the new surface water supply from the KWSP, has gained access to improved groundwater availability. Khulna City still needs to extend the network to another 21,000 households or properties for complete coverage in the city, as well as keep pace with demand as it increases with rapid urbanization in Bangladesh.

Connections. Of the 40,000 installed connections under the KWSP, 25,941 were first-time connections, and 2,206 previously illegal connections were legalized. Another 11,853 connections were replacement connections. A total of about 190,000 households or 1 million people benefited from the domestic connections. The total number of non-domestic connections after the project was 533, of which 138 were previously illegal non-domestic connections made legal and 10 were first-time non-domestic connections.

Inclusive improvement. In low-income communities, where individual household connections were not practical, the KWSP provided 250 metered connections to supply shared community taps with treated, 24/7 water supply, covering around 10,000 households. A water user group (WUG) was formed for each community connection to maintain the tap, report issues to KWASA, and collect charges from the households for paying the monthly bill. Of the project beneficiaries, 6,500 low-income households headed by women were also connected to the piped network system. Women share nearly equal leadership and membership numbers in the groups, with 45% of members and 45% of leadership positions held by women. As a result, the average daily time to fetch water—a burden most often designated to women and children—was reduced from 90–120 minutes per day on average to less than 20 minutes per day.

Economic benefits. An analysis of the economic benefits of the improved water supply found that the average household costs of fetching water (for those households who benefited from improved access to either a new household or shared community connection) fell from Tk622 to zero per month. In addition, for new households with piped connections, the valued costs of labor from not using hand tube wells were reduced from Tk18,000 to zero per month.

Health benefits. With the improved water supply, the spread of the two significant and common waterborne diseases, i.e., diarrhea and dysentery, have been reduced significantly. Only about 6.5% of sampled households have been affected by diarrhea or dysentery since project completion, compared to 16.8% of households affected by diarrhea and 15.3% affected by dysentery before the project.

Taking Care of Business

Crucial to long-term, post-project viability was a phased volumetric tariff structure to put KWASA on the trajectory to full cost recovery. Prior to the KWSP, domestic customers paid a flat-rate cost of Tk68 (about $0.79 in 2021 currency terms) per month. As a result of the project's support for strengthening KWASA's corporate business plan (CBP), KWASA implemented a new volumetric tariff. The tariff structure does not utilize an increasing block tariff (higher usage, higher tariff per unit of water) to avoid adversely affecting shared connections in low-income communities. The tariff, starting at Tk6.91/m^3 in 2020 ($0.08/$m^3$ in 2021 currency terms), will increase 5% annually until 2025 when KWASA expects to reach a level that fully recovers the operation and maintenance (O&M) costs. To improve revenues, KWASA also registered all illegal connections, converted to billing per household, and began charging owners of private deep and hand tube wells.

Ongoing, intensive staff training has resulted in a 30-minute average response time to customers' complaints. In addition, KWASA has hired 95% of the posts in the human resource development plan (with equal opportunity to male and female applicants) and reports a 95% tariff collection rate.

Lessons

Cities and water supply service providers across South Asia and the wider region face a similar challenge as Khulna City with salinity intrusion and groundwater overextraction. As cities and water supply service providers shift from groundwater reliance to surface water development, the structure of their service organizations changes radically, along with staff needs and skills sets. The experiences of preparing and implementing the KWSP resulted in lessons that would be especially interesting for other municipal water supply service providers facing similar challenges as KWASA was before the project. A few of the especially salient lessons from the main report are summarized here.

Study the problem as upstream as possible for better design and greater readiness. The various studies undertaken by the government, independent organizations, ADB, and JICA are examples of detailed and diligent analysis undertaken to identify various options for the project design. Unfortunately, such diligent upstream studies may be overlooked by some projects in the interest of time or mistaken certainty based on historical bias or outdated information and knowledge. Taking time to conduct the upstream studies as done for KWSP will result in better-designed projects and ensure a higher project readiness of implementing agencies.

Anticipate challenges, advance action if possible, on land acquisition. About two-thirds of the land identified for KWSP was owned by one family willing to sell to the municipality, while the other smaller landholders were less willing. The KWSP faced initial delays from residents and advocate groups who objected the project's resettlement plans. Implementing agencies that are new to the resettlement policies and procedures of international development partners should expect organized public resistance against resettlement. ADB and its developing member countries can now take advantage of the "advanced action" option when projects are in an early inception phase. Advanced actions also enable capacity building of the government entities that are likely to be implementing near-term ADB-financed investments.

Communicate early, often, and clearly on intergovernmental approvals. The KWSP met what seems to have been its most consequential delays from securing the necessary permissions from other government departments and entities to lay the transmission mains. Implementing agencies should communicate early and often with systematic information about the project with other government entities of which memorandums of understanding and approvals will be needed.

Give new implementing agencies additional implementation time, especially for TA components that involve extensive planning, consensus building, and training. Initially, the TA attached to the KWSP was to be implemented over 7 months to support KWASA during the project's initial stage, particularly in strengthening KWASA's business strategy. ADB extended the TA by 38 months (with no additional cost requirements) as KWASA's institutional and staff capacity needs became more apparent. Implementing agencies with limited experience in designing or implementing large infrastructure projects or internationally financed projects require more TA resources and time to implement, as the scope of needs changes and grows over time.

Larger packages improve international competitive bidding. KWASA leadership has said that the international bidding process was arduous and complicated because it had never been engaged in international competitive bidding or procured to ADB's standards. KWASA found that civil works for some of the conveyance works could have been grouped into bigger packages to attract contractors with international reputations, higher qualifications, more substantial financial resources, and more experience in large civil works contracts. Fewer but larger contracts will reduce the risk of contract implementation and the time in managing several contracts. In addition, taking additional time and careful preparation of bid documents and bid reviews will help recruit quality contractors.

In large-scale network expansions, especially in dense urban poor areas, ground-truth project ideas and plans. ADB's preference is for individual household connections, which are the optimal choice for increasing the socioeconomic benefits of the water supply. The spatial limitations of Khulna's streets and low-income areas were an unexpected challenge for KWASA to install as many household connections as initially planned under the KWSP. KWASA opted for 250 new metered connections for shared community water taps (piped, metered, treated surface water) for approximately 10,000 households in place of household or property connections for these areas. Rigorous scoping of low-income communities within the project area is important to test the feasibility of project ideas and plans. Consultations are also essential to conduct with target beneficiaries, especially women, who are primarily responsible for water collection during the project design phase.

Unfinished Business

Interviews with key stakeholders of the KWSP identified opportunities for KWASA and development partners to further strengthen the coverage, operation, and sustainability of water supply services in Khulna City. Some of KWASA's unfinished business items will be familiar to many urban water supply providers that struggle with expectations of modern water supply services: whereby 100% coverage, full cost recovery, autonomy, and private sector engagement are becoming the norm but still need renewed commitment and championing.

Expanding household connectivity and supply. Approximately 35% of Khulna City households are still not connected to the household distribution system because they are in uneconomic locations within the service area. With the new surface water source augmenting supply throughout the city, households that do not gain access to the new surface water supply are able to access improved quality and availability of groundwater. KWASA needs to expand the existing surface water treatment plant and distribution network to achieve 100% access to piped water supply within its service area.

A longer horizon for the corporate business plan. The CBP requires substantial updates before KWASA submits it to the government for approval; the CBP needs to be extended beyond its current 2020 time frame, providing new projections on O&M costs, revenue collection, nonrevenue water rates, etc., to justify its financial and human resource needs and plans. In the meantime, KWASA has relied on legal provisions under the WASA Act to implement the necessary tariff increases and the government's specific approval for staff hiring. The tariff structure and organogram are two important aspects of the CBP that drive the quality of KWASA's O&M of the newly established water supply system.

But to submit the CBP for approval, KWASA needs to update much of the data in the current plan in order to justify its financial and human resource needs and plans.

Enhancing operational sustainability. KWASA's CBP has estimated annual O&M expenditures to be $3.25 million from 2025 onward, including personnel expense, power cost, chemical cost, and maintenance cost, among others. Until 2025, O&M costs are expected to be incurred in proportion to the water produced at the new surface water treatment plant. To finance the O&M costs, KWASA needs to follow its scheduled water tariff increases. KWASA plans on retaining O&M work internally while many larger urban utilities across the region and the world are turning to various types of O&M contracts with the private sector. For example, civil works packages for both water treatment plant and the piped network in recent ADB-financed water supply projects in India, Bangladesh, and other countries often include O&M for 5–10 years, with the contractors responsible for design, build/construct, and O&M (design–build–operate contracts). Private sector engagement in O&M can be a tool to ensure efficient and professional operation that KWASA may need to consider.

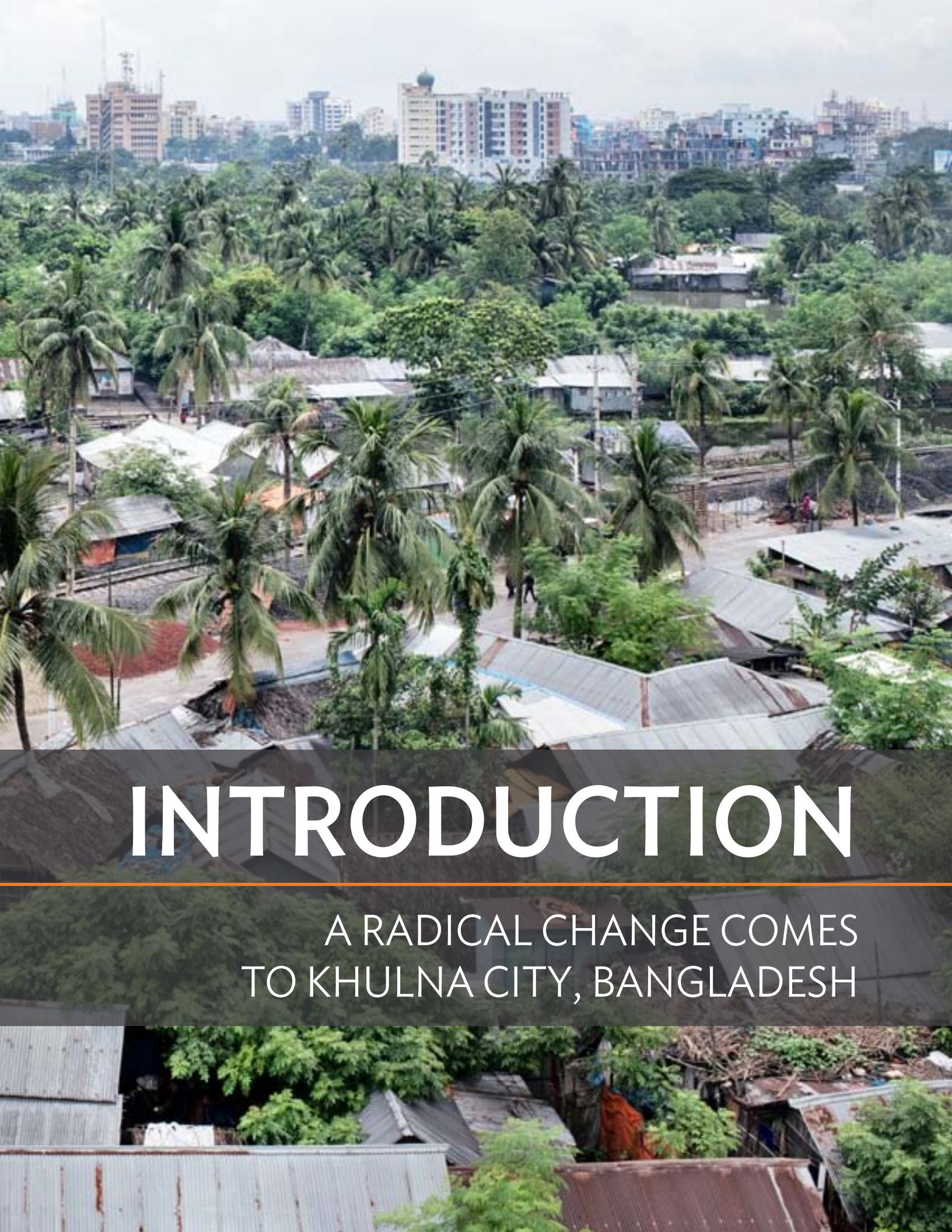
Summary Profile of Khulna Water Supply System and Operations

Profile Indicators	Before Project (2010)	After Project (2019)
Population with access to treated piped water supply (%)	<20	65
Hours of piped water supply per day (hours/day)	5.3	24
Water supply per capita per day (lpcd)	45	113
Average daily minutes spent fetching water (minutes/day)	90–120	<20
Total KWASA groundwater abstraction (MLD)	119	50
Total KWASA production capacity (MLD)	69	160 (110 MLD from surface water and 50 MLD from groundwater)
Nonrevenue water (%)	36	20
Average tariff (Tk)	68/month (flat rate)	6.91/m^3 (volumetric)

KWASA = Khulna Water Supply and Sewerage Authority, lpcd = liter per capita per day, m^3 = cubic meter, MLD = million liters per day, Tk = taka.

Sources: ADB. 2011. *Preparing the Khulna Water Supply Project*. Consultant's report. Manila (TA 7385-BAN); ADB. 2020. *Completion Report: Khulna Water Supply Project in Bangladesh.* Manila.

Overview of Khulna City. Bangladesh's third-largest city, the Khulna metropolitan area, is home to an estimated 1.5 million people. More than a thousand slums proliferate on the outskirts of the city, beyond the reach of reliable public utility service.



INTRODUCTION

A RADICAL CHANGE COMES TO KHULNA CITY, BANGLADESH

Pump house. Three continuously running, 250 kW pumps at the intake structure and pump house along the Madhumati River in Bagerhat, near Mollarhat, collect surface water at a rate of 129,600 m^3/day. On standby is a fourth pump.

"Radical change" is how Mohammad Abdullah, the managing director of the Khulna Water Supply and Sewerage Authority (KWASA) repeatedly describes the citywide effect of the Khulna Water Supply Project (KWSP), cofinanced by the Asian Development Bank (ADB) and the Japan International Cooperation Agency (JICA). The KWSP overhauled the city's entire water supply system, transitioning it from a reliance on unsustainable and insufficient groundwater to a new surface water source. KWASA customers now have access to 24/7, treated freshwater of the highest quality standard. Figure 1 illustrates the wide scope of KWSP, representing an entire urban water supply system, from intake facility to household and shared community ("cluster") connection. See Figure 2 for a list of project milestones.

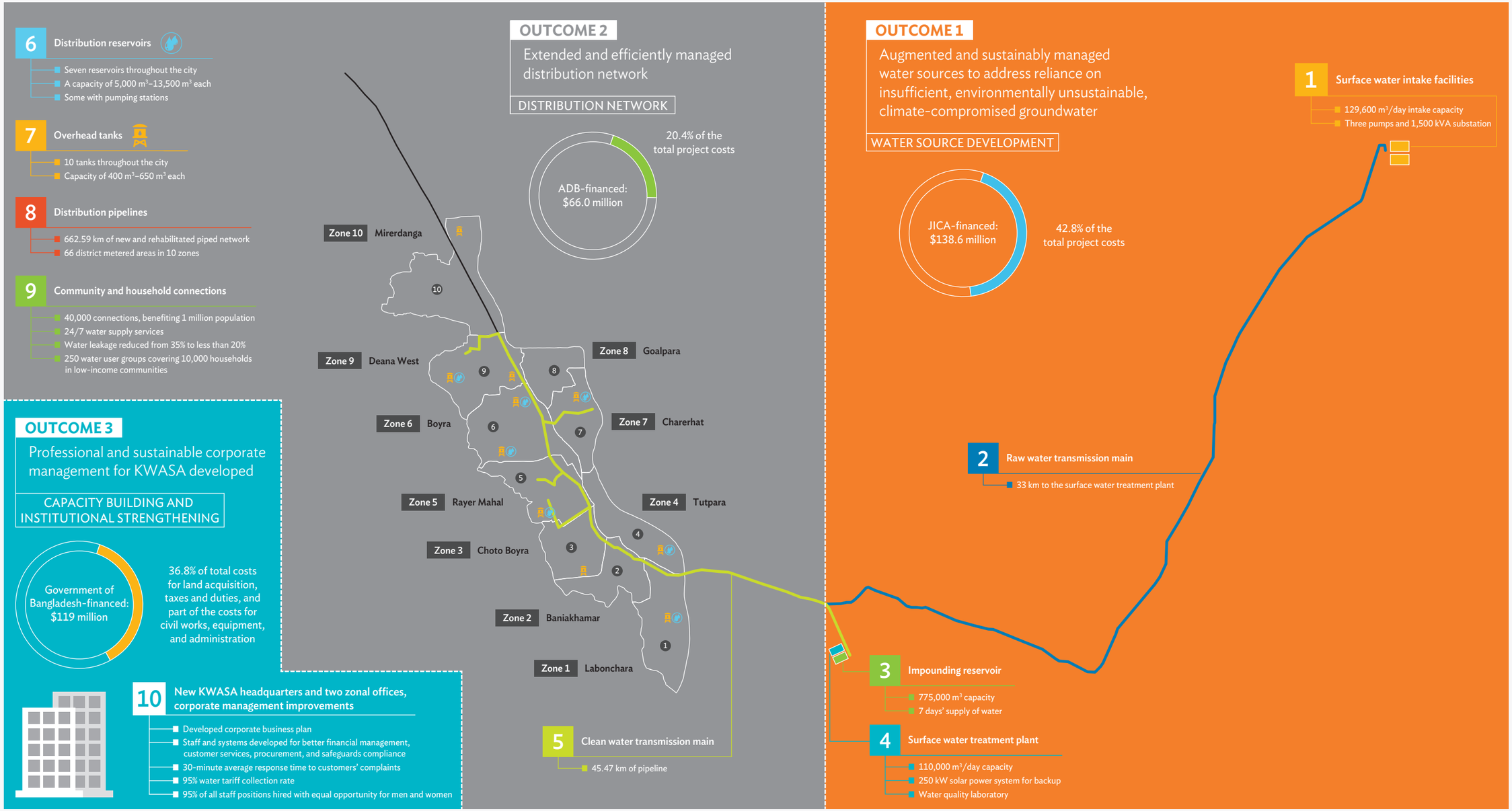
The KWSP invested heavily in the professionalization of KWASA and increased the availability of piped, metered, and treated water to residents of Khulna by 65%, with expansions ongoing. Households that experienced an average of just 5.3 hours per day of low-pressure, intermittent, and poor-quality water supply now receive 24/7 clean drinking water. Households in low-income communities, previously not connected to the network, have also gained access to treated surface water through community-managed, metered, and shared connections (cluster connections) that have reduced people's time (mostly women's time) fetching water daily from as high as 120 minutes to just 20 minutes. The project completion report indicates that the intended targets and results of KWSP were either met or exceeded. Transformational development is the aspiration of ADB's Strategy 2030, which identifies "making cities more livable" as one of its seven operational priorities.[1]

The complete overhaul of Khulna City's water supply system could not have been more timely. Nearly 6 months after the system's full commissioning in July 2019, the coronavirus disease (COVID-19) pandemic became a global public health crisis, and at an exceptional scale of devastation to people living in cities, where densely populated communities faced higher risks of exposure to the potentially deadly virus. The public health and economic crisis set off by the COVID-19 pandemic has placed cities, like Khulna, at the epicenter of traumatic impact and recovery. Less than a year before the pandemic began, Khulna City was still relying on only around 5 hours of water availability per day. "If the piped 24/7 water supply had not been done by KWSP when the pandemic hit, the people would have been in a very different situation. They would have been far more vulnerable," said Sudhir Khumar Ghosh, the project management consultant for KWSP and the former chief engineer of the Department of Public Health Engineering.

In Asia and the Pacific, cities like Khulna are confronted with economic stagnation and climate displacement. Nowhere are these risks and real impacts more acutely experienced than in urban slum communities, which are most often outside the coverage areas of urban services while in the direct path of environmental hazards. Unsustainable groundwater abstraction and saline intrusion are challenges that require governments to invest in radical changes in how water resources are developed and delivered. Without equitable and sustainable urban basic services, cities will not prosper, and low-income communities will continue to bear the heaviest burden of water poverty. This report on the KWSP is a retrospective of how designs, implementation, and increased technical capacity of KWASA, and enhanced awareness of the general public, have contributed to the improved livability and resiliency of Khulna City and its people through improved access to clean and sustainable water supply services. The KWSP is an example of how other cities should engage in finding alternatives to the natural and chronic water challenges.

[1] Asian Development Bank (ADB). 2018. *Strategy 2030: Achieving a Prosperous, Inclusive, Resilient, and Sustainable Asia and the Pacific.* Manila.

Figure 1: Map-Based Infographic of New Water Supply System for Khulna City



ADB = Asian Development Bank, km = kilometer, kVA = kilovolt-ampere, kW = kilowatt, KWASA = Khulna Water Supply and Sewerage Authority, lpcd = liter per capita per day, m³/day = cubic meter per day, mm = millimeter.

Source: ADB. 2020. *Completion Report: Khulna Water Supply Project in Bangladesh*. Manila.

Figure 2: Key Milestones

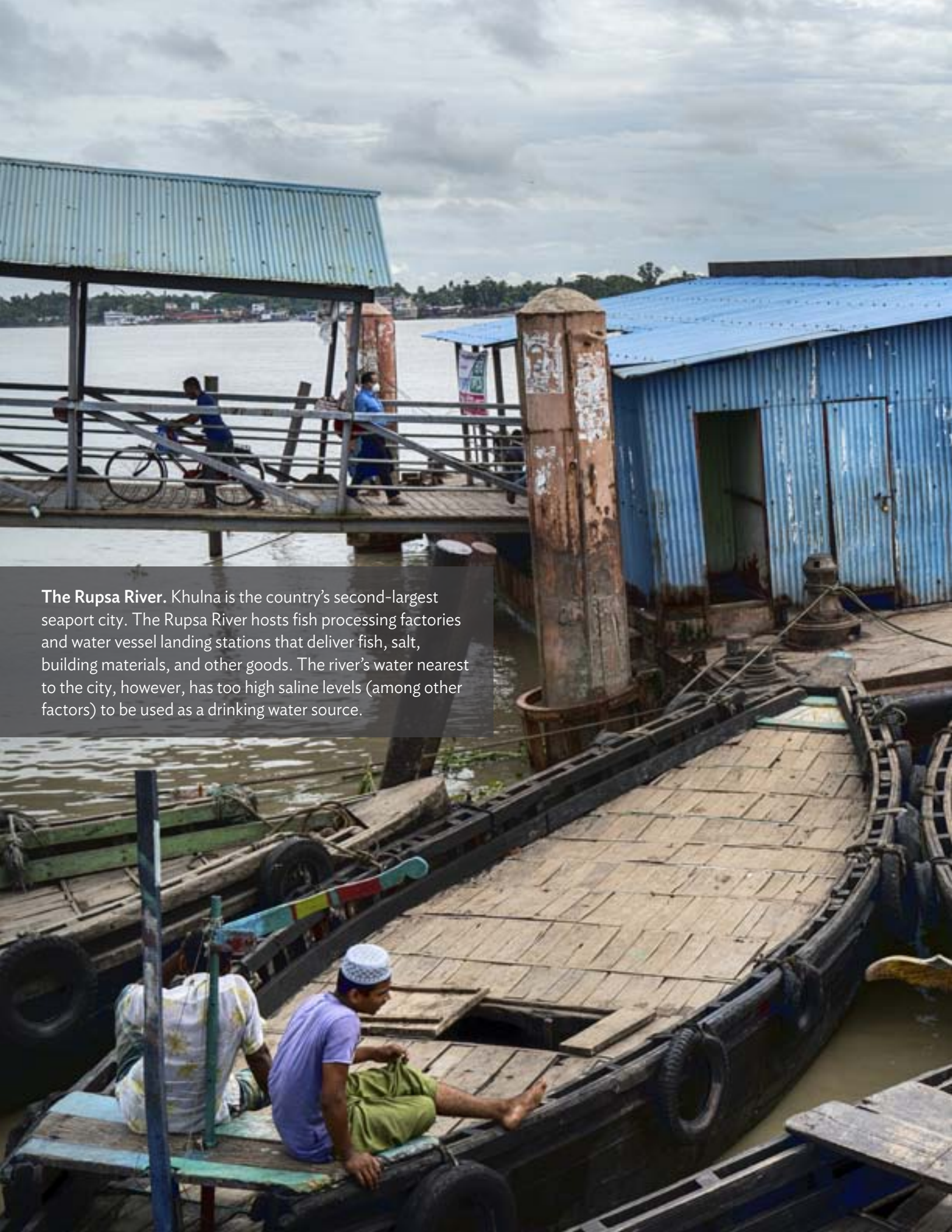
Date	Milestone
November 2007	ADB leads formulation of Joint Partnership Framework for Urban Water Supply and Sanitation Sector in Bangladesh.
March 2008	The government establishes KWASA through statutory regulation order.
October 2008	The Khulna City Corporation transfers human resources, physical assets, and financial accounts of its water works division to KWASA.
December 2008	ADB approves a small-scale, $225,000 TA to support the establishment of KWASA.
December 2008	ADB approves a $720,000 TA to study climate scenarios and identify climate adaptation options for Khulna City.
November 2009	ADB approves an $800,000 project preparatory TA to assist KWASA in preparing the KWSP for Khulna City.
June 2011	ADB approves a loan of $75 million for the KWSP and a TA of $700,000.[a]
January 2012	Loan becomes effective.
May 2018	Construction completed for KWASA headquarters and two zonal offices.
June 2018	Original project closing date.
April 2019	Construction completed for treated water transmission main, including river crossing.
May 2019	Construction completed for intake, transmission main, surface water treatment plant.
June 2019	Construction completed for distribution system (reservoirs, overheads, piped networks).
June 2019	Meter installation completed.
June 2019	Project completion, commissioning of water supply system.
December 2019	Financial closure of loan.
September 2020	ADB approves a loan of $160 million for Khulna Sewerage System Development Project.

ADB = Asian Development Bank, JICA = Japan International Cooperation Agency, KWASA = Khulna Water Supply and Sewerage Authority, KWSP = Khulna Water Supply Project, TA = technical assistance.

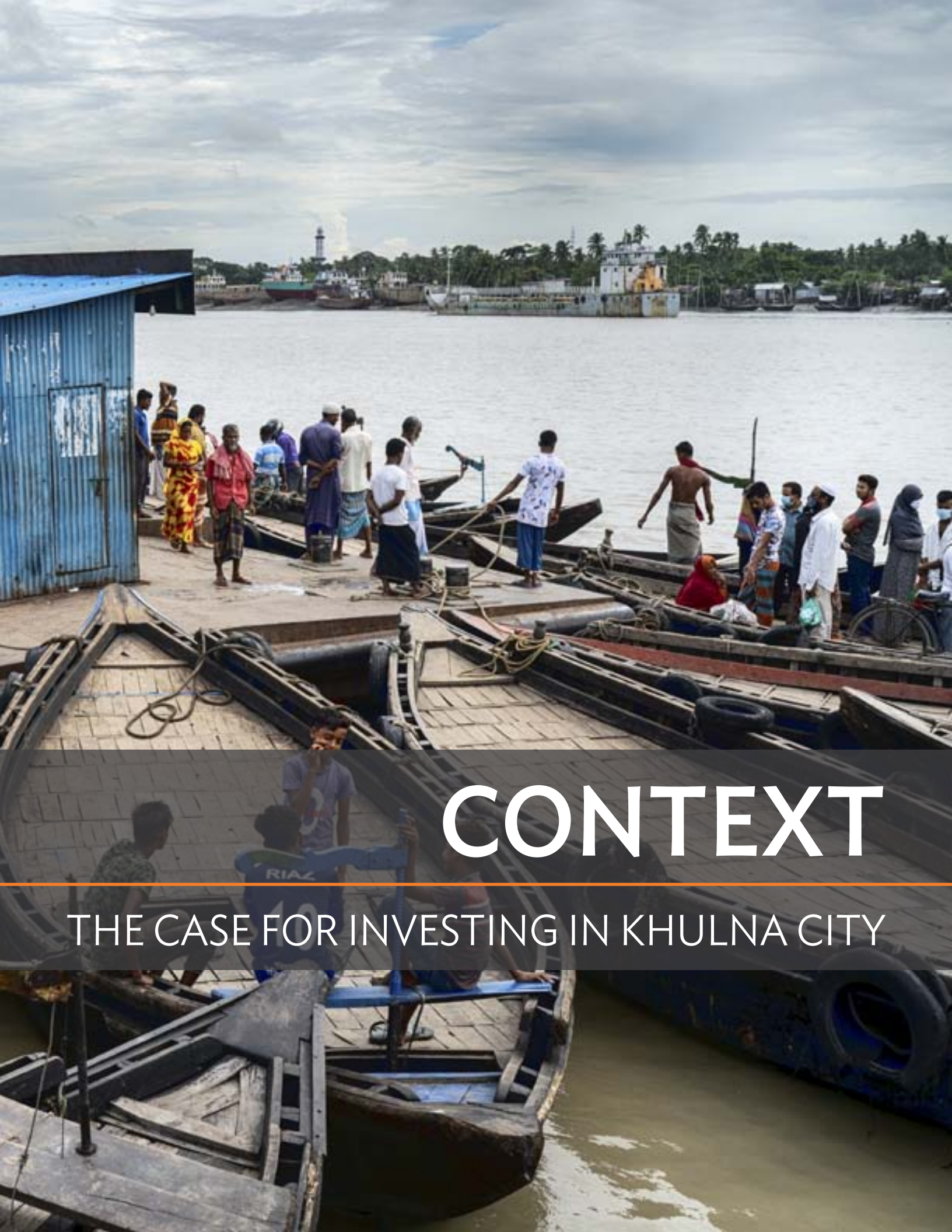
[a] The total, original investment cost was $363.5 million, of which ADB share of financing was estimated at about 20.6%, JICA's financing was estimated at $184.0 million or 50.6% of the project, and government financing was estimated at $104.6 million or 28.8%.

Source: Asian Development Bank.

Modern operation and maintenance. Md. Saiduzzaman, a process operator, checks a new unit control panel of the Bangabandhu Water Treatment Plant established under the Khulna Water Supply Project.



The Rupsa River. Khulna is the country's second-largest seaport city. The Rupsa River hosts fish processing factories and water vessel landing stations that deliver fish, salt, building materials, and other goods. The river's water nearest to the city, however, has too high saline levels (among other factors) to be used as a drinking water source.



CONTEXT

THE CASE FOR INVESTING IN KHULNA CITY

Situated in southwest bangladesh in the Ganges River Delta, Khulna City is of strategic economic importance (Map 1). It is the country's third-largest city and third-largest economy. Being 160 kilometers (km) from Kolkata, India, and 275 km from the capital city of Dhaka, Khulna City is host to the country's second-largest port. It is a gateway to the world's largest mangrove forest, the Sundarbans, where the Bengal tiger is the main tourist attraction, and is an hour's drive southward to the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site of the medieval "Mosque City of Bagerhat."

Khulna's prospects for greater domestic and foreign investment are rising. In January 2020, plans to construct an 800-megawatt combined cycle liquid natural gas power plant in Khulna were announced. The country's longest bridge, the Padma Multipurpose Bridge, is scheduled to be commissioned in 2022, linking the country's southwest with the central and eastern regions and integrating economies of the more industrialized and urbanized eastern regions and cities such as Dhaka, Chattogram,[2] and Sylhet, with the largely rural and agricultural western regions, including Khulna District, of which Khulna City is the administrative seat.[3] Four economic zones have been established or proposed in and near Khulna City to service the expected rise in industrial and commercial activities from the Padma Multipurpose Bridge.

The economic and employment potential of Khulna will continue to attract more labor from rural areas, people who are looking to escape poverty. The 2011 national census counted 663,342 in the city center and 1.04 million people in the larger Khulna metropolitan area, with the 2020 population estimated at 1.5 million.[4] The Khulna City Corporation (KCC) area, almost 46 square kilometers (km^2), is divided between well-serviced and under-serviced areas. Being the third-largest city and the second-largest port in the country, Khulna has one of the largest concentrations of slum and informal settlements—1,134 slums, mostly on the periphery of the city center.[5] Infrastructure and public services (water, power, roads) are least dependable or available to low-income areas.

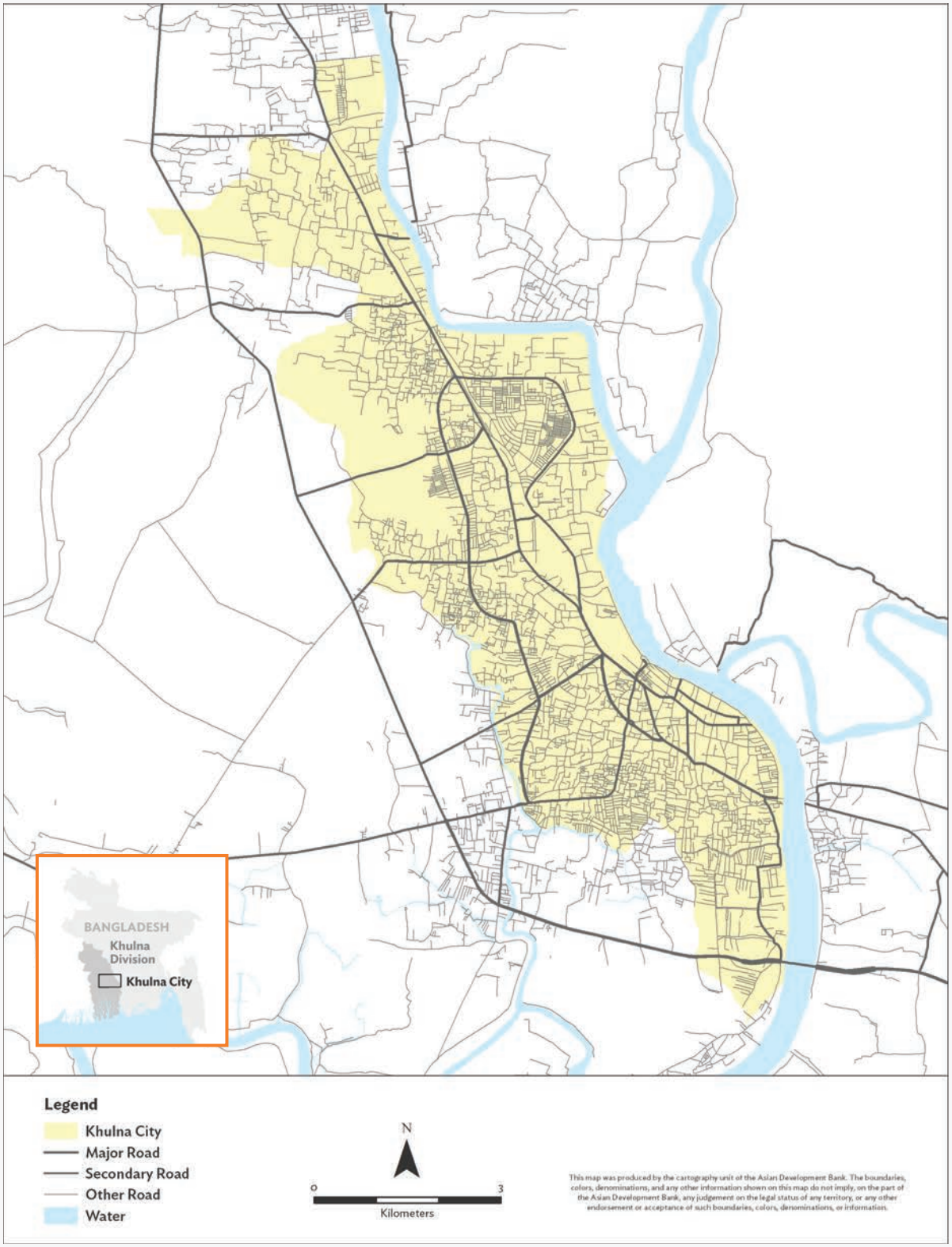
[2] Formerly Chittagong; name was officially changed in 2018 to represent its Bengali pronunciation. This publication uses Chattogram.

[3] K. G. Moazzem. 2020. Padma bridge, a new development frontier for Bangladesh. *The Financial Express.* 30 December. https://thefinancialexpress.com.bd/views/padma-bridge-a-new-development-frontier-for-bangladesh-1609340224.

[4] Government of Bangladesh, Bangladesh Bureau of Statistics. 2011. *Population & Housing Census-2011.* The projected 2020 population was 1.19 million, however, the current population is commonly believed to have exceeded this projection and is likely to be closer to 1.5 million due to rapid urbanization and in-migration.

[5] T. Sowgat and S. Roy. 2020. *Khulna: the diversity and disparity of neighbourhoods from organic growth (SHLC Research Summary 09).* Glasgow: Centre for Sustainable, Healthy, and Learning Cities and Neighborhoods. http://www.centreforsustainablecities.ac.uk/research/khulna-the-diversity-and-disparity-of-neighbourhoods-from-organic-growth/.

Map 1: Map of Khulna City



Source: Asian Development Bank.

Changing reality. For Khulna City to live up to its economic potential, it had to resolve its issues, which would hold back economic growth but also public health and individual prosperity. Households were spending precious income on third-party water suppliers, medical treatment for water-related illnesses, and hours waiting in line on multiple trips to haul water from drying up tube wells.

Understanding Poverty in Khulna

The government's 8th Five Year Plan (2021–2025) reports sharp reductions in poverty in the larger Khulna Region between 2000 and 2016 (a 17.4% decline), especially in reducing extreme poverty (a 20.1% decline). The poverty rate in Khulna fell from 45.1% in 2000 to 27.7% in 2016; over the same period, the extreme poverty rate in Khulna fell from 32.2% to 12.1% (Table 1). The improvements in poverty rates were largely the outcome of per capita gross domestic product and job growth, which had surged between 2000 and 2010, even in the agriculture sector, but slowed in the decade that followed due to a slower economic growth.[6]

Table 1: Poverty Incidence in Khulna Region, 2000–2016
(%)

	2000	2005	2010	2016	Total Change
Poverty	45.1	45.7	32.1	27.7	17.4
Extreme poverty	32.2	31.6	15.4	12.1	20.1

Source: World Bank. 2019. *Bangladesh Poverty Assessment: Facing Old and New Frontiers in Poverty Reduction, Volume 2*. Washington, DC.

[6] Government of Bangladesh. 2021. *8th Five Year Plan.* Dhaka.

Seeking prosperity in the city. Khulna has one of the largest concentrations of slum and squatter settlements—1,134 slums, mostly on the periphery of the city center, as of 2020.

Khulna City and its surrounding region are vulnerable to poverty because of people's heavy reliance on informal and agricultural incomes. The Khulna Region is also uniquely vulnerable to climate change impacts and disasters, which disrupt productivity and incomes. One of the most definitive studies on slums in Bangladesh[7] reported in 2005 that Khulna City had about 520 slums; about 20% of the city's population (188,442 people or 37,826 households) were living in slums. About 80% of these slums in Khulna City had existed before 1990 and about 27% date back to 1971 or earlier. One of the largest concentrations of slum communities is along the railway that cuts through the middle of the city. Whether large or small concentrations, slum population density is high. The average number of persons per km^2 in Khulna slums is about seven times higher than the city's average population density—132,988 per km^2 in slums compared to 21,218 per km^2 urban average. ADB's Water Policy[8] and forthcoming Water Sector Framework, 2021–2030 strongly suggest household water connection over shared access points, but Khulna City's high population density can make 100% public service delivery at a household level difficult.

[7] N. Islam et al. 2006. *Slums of Urban Bangladesh: Mapping and Census, 2005.* Dhaka, Bangladesh and Chapel Hill, US: Center for Urban Studies. National Institute of Population Research and Training, and MEASURE Evaluation. The studies define a slum as residential area of at least 10 households or a single housing unit with at least 25 residents characterized by predominately poor housing, high population density, and crowded living conditions; a lack of basic, quality environmental services, especially water and sanitation facilities and services; low income levels among most residents; and lack of secure tenure.

[8] ADB. 2003. *Water for All: The Water Policy of the Asian Development Bank.* Manila.

Lacking Economic Competitiveness

Although Khulna is the headquarters of one of the country's few districts to have industrialized and is one of 12 city corporations to receive priority socioeconomic development support from the central government, it is not considered as one of the country's most competitive (growing) cities. In a 2011 study by ADB of the country's top 10 cities, Khulna was one of six cities that scored less than 6 out of 10 on the index.[9] One of the major factors is that industrial production in Khulna is mainly limited to local consumption. At the time of the study, the city's chronic water supply problem was also a major deficiency, undermining Khulna's urban performance and prospects.

Climate Risks

Located in the country's coastal belt, Khulna City experiences some of the country's greatest climate risks and vulnerabilities. Increasing sea levels are also likely to exacerbate the issue of salinity intrusion, which is already a perennial problem for Khulna's rivers, groundwater, and soil. Mayor Talukder Abdul Khaleque counted the city's numerous water-related issues as the greatest obstacles to the development and growth that he envisions for the city. "Our groundwater was in crisis from overextraction. Being a coastal city, we faced water problems with salinity intrusion. Khulna water was also contaminated by solid waste and wastewater, prior to the KWSP," he told ADB in interviews for this publication.

Depletion: Depending on Groundwater

Until the assets developed under KWSP were fully commissioned in July 2019, all households in Khulna City had been relying entirely on groundwater resources, whether their access points were household piped water connections, shared community tap stands, hand-pump tube wells, or private wells (Table 2). Based on a sample survey of water sources across the entire KCC area, the total groundwater extraction in 2010 was estimated to be 119,100 cubic meters per day (m^3/day); extraction beyond 50,000 m^3/day is environmentally unsustainable—the amount of groundwater being extracted was exceeding the environment's natural recharge rate, risking eventual depletion.[10] "The situation with groundwater was getting worse every year," the mayor said. "Only less than one-fifth of the population had access to piped water," which was widely and publicly lamented for its poor quality, high salinity, and limited availability—a few odd hours per day and with inconsistent water pressure.

Table 2: Groundwater Extraction by Method and Volume in 2010

Groundwater Source	Volume per Day
KWASA-owned deep tube wells	30,100 m^3
KWASA-owned hand tube wells	39,300 m^3
Others, i.e., private wells	49,700 m^3
Surface water	–
Total	**119,100 m^3**

KWASA = Khulna Water Supply and Sewerage Authority, m^3 = cubic meter.

Source: Japan International Cooperation Agency. 2011. *Feasibility Study for the Khulna Water Supply Improvement Project: Final Report, Vol. 1, Summary*. p. S–18.

[9] ADB. 2011. *Competitive Cities in the 21st Century: Cluster-based Local Economic Development*. Manila. p. 265. https://www.adb.org/sites/default/files/publication/29242/cluster-based-local-economic-development.pdf.

[10] Japan International Cooperation Agency. 2011. *Feasibility Study for the Khulna Water Supply Improvement Project: Final Report, Vol. 1, Summary*. Tokyo.

August 2021 storm. Located in the country's coastal belt, Khulna City experiences some of the country's greatest climate risks, vulnerabilities, and exposure levels.

Salinity Damage

Saline intrusion is a natural characteristic of groundwater and surface water in Khulna City. Low-lying swamps and marshes in the city's northwest are a major topographic feature, and all the rivers surrounding the city are tidal. A 2011 study by the Institute of Water Modeling confirmed that three aquifer layers exist in Khulna City, though there is no further extraction potential in the first (upper) and second (middle) aquifers due to saline levels.[11] The KCC, prior to the KWSP, used the first and second aquifers: at the maximum of 209,704 m^3/day, of which 103,259 m^3/day was from the shallow aquifer and 106,445 m^3/day from the middle aquifer. In general, the depth of these layers is above 250 meters (m). The third layer, the deep aquifer, exists below 250 m and has a reasonable thickness of about 100 m, with an area spread over about 97 kilometers (km). The sandy layers are more granular than the more shallow aquifers, acting as an impervious layer against salinity intrusion. The deeper aquifer is the confined type and was considered a possibility for fresh groundwater resources.

Studies have found a significant correlation between hospital visits in southern coastal Bangladesh; high salinity and total dissolved solids in drinking water; and incidents of cardiovascular diseases, diarrhea, abdominal pain, and hypertension.[12] The studies also found that participants living in the high-salinity areas showed significantly lower levels of awareness about the health effects of drinking excess saline (though not statistically significant lower levels of education and income) than participants living in low-salinity areas (footnote 12).

[11] ADB. 2011. *Preparing the Khulna Water Supply Project.* Consultant's report (on the groundwater assessment by the Institute of Water Modeling). Manila (TA 7385-BAN).

[12] R. Chakraborty, et al. 2019. Health Implications of Drinking Water Salinity in Coastal Areas of Bangladesh. *International Journal of Environmental Research and Public Health*. 16(9). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6801928/#B7-ijerph-16-03746.

Lacking Water, Lacking Service

Prior to the KWSP, the city's entire population had been relying on groundwater sources such as deep and hand tube wells owned by KWASA, street hydrants, and private tube wells (Table 3). Typically, the women in households spent a daily average of 90 minutes fetching water, with poorer households spending as much as 120 minutes fetching water every day. Only less than 20% of this city's population had access to piped water supplies from the official municipal service. KWASA was formed in March 2008 to relieve KCC of water supply responsibilities. "We had such low coverage because there was no water, only groundwater, and we had issues with depleting water tables and salinization," said Mohammad Abdullah, the managing director of KWASA.

Table 3: Water Access by Type and Population in Khulna City in 2010

Calculation of Served Population	Numbers	Remarks
KWASA-owned deep tube wells for connections		
1. Registered connections	15,032	(i) + (ii)
(i) Inactive connections	2,579	
(ii) Active connections	12,453	
2. Consumers per each	13.7	
3. Served population	171,100	(ii) x (2)
KWASA-owned deep tube wells for street hydrants[a]		
4. Total connections	503	(i) + (ii)
(i) Inactive connections	403	
(ii) Active connections	100	
5. Consumers per each	100	
6. Served population	10,000	(ii) x (5)
KWASA-owned hand tube wells		
7. Number of deep hand tube wells	3,748	
8. Number of shallow tube wells	5,538	
9. Consumers per each	30	
10. Served population	278,600	[(7) + (8)] x (9)
Private tube wells		
11. Number of private wells	13,733	
12. Consumers per each	30	
13. Served population	412,000	(11) x (12)
Uncategorized population[b]	**85,300**	
Total	**957,000**	**(3)+(6)+(10)+(13)+Uncategorized population**

[a] "Street hydrant" refers to public-access water sources for the vulnerable, transitory population. The street hydrants are connected to the piped water supply system from which water is sourced from deep tube wells.

[b] "Uncategorized population" refers to the population whose water source could not be identified at the time of the 2010 feasibility study.

Source: Japan International Cooperation Agency. 2011. *Feasibility Study for the Khulna Water Supply Improvement Project: Final Report, Vol. 1, Summary*. p. S-6.

Whether a household's water access point was a private house connection that supplied piped water or a communal tap stand, residents were living without clean, sufficient water supply. The system was old and not properly maintained, and the water quality was poor because of salinity, pipeline leakage, low pressure, and unsatisfactory availability. A major factor of the poor water quality and service levels was the age and poor maintenance of the infrastructure. At least 36% of the system's water was lost in distribution, about 20,940 m^3/day (Table 4). A 2008 ADB household survey found that connected households received water for only 5.3 hours per day; unsurprisingly, 75% of connected households said the supplied quantity was not enough to meet their daily needs.[13] "We had so many problems with water, and we were never really able to do anything about them," Mayor Talukder said. "We studied how to resolve this, and it was always a priority, but groundwater was always our solution." Groundwater, however, was not a viable solution. More wells and deeper wells were a status quo, temporary fix that would bear a legacy of environmental consequences.

Table 4: Water Usage by Source in Khulna City in 2010

Water Source	Water Use	Remarks
KWASA-owned deep tube wells	Number of consumers: 171,100 + 10,000 = 181,100 Supply amount = 30,100 m^3/day Water loss = 30,100 x 0.40 = 12,040 m^3/day Net water supply = 30,100 – 12,040 = 18,060 m^3/day Non-domestic = 18,060 x 0.20 = 3,610 m^3/day Domestic = 18,060 – 3,610 = 14,450 m^3/day Lpcd = 14,450 x 1,000/181,100 = 80 lpcd	Water loss: 40%
KWASA-owned hand tube wells	Number of consumers: 278,600 Supply amount = 39,300 m^3/day Water loss = 39,300 x 0.10 = 3,930 m^3/day Net water supply = 39,300 – 3,930 = 35,370 m^3/day Non-domestic = 35,370 x 0.20 = 7,070 m^3/day Domestic = 35,370 – 7,070 = 28,300 m^3/day Lpcd = 28,300 x 1,000/278,600 = 102 lpcd	Water loss: 10%
Private tube wells	Number of consumers: 412,000 Supply amount = 49,700 m^3/day Water loss = 49,700 x 0.10 = 4,970 m^3/day Net water supply = 49,700 – 4,970 = 44,730 m^3/day Non-domestic = 20%: 44,730 x 0.20 = 8,950 m^3/day Domestic = 44,730 – 8,950 = 35,780 m^3/day Lpcd = 35,780 x 1,000/412,000 = 87 lpcd	Water loss: 10%
Total	Number of consumers: 871,700 Water supply amount = 119,100 m^3/day Water loss = 20,940 m^3/day Net water supply = 98,160 m^3/day Non-domestic = 19,630 m^3/day Domestic = 78,530 m^3/day Lpcd = 78,530 x 1,000/871,700 = 90 lpcd	

KWASA = Khulna Water Supply and Sewerage Authority, lpcd = liter per capita per day, m^3/day = cubic meter per day.

Source: Japan International Cooperation Agency. 2011. *Feasibility Study for the Khulna Water Supply Improvement Project: Final Report, Vol. 1, Summary*. Tokyo.

[13] ADB. 2008. *Technical Assistance to Bangladesh for Supporting the Establishment of Khulna Water Supply and Sewerage Authority*. Manila. The survey covers 3,000 households randomly selected in Khulna City.

Khulna's Water Problem Gains Attention

The needs and demands of Bangladesh's urban development require strategic planning and coordination. ADB has consistently invested in the country's urban water supply and sanitation sectors. In November 2007, ADB initiated the Joint Partnership Framework for Urban Water Supply and Sanitation, in which the government and several international development partners agreed to focus on the development of the water supply and sewerage authorities in the country's three largest cities (Dhaka, Chattogram, and Khulna).[14] ADB would lead support in Khulna City.

The government recognized the seriousness of Khulna City's limited and compromised water supply and established KWASA in March 2008, the third of its kind in Bangladesh following Dhaka and Chattogram water supply and sewerage authorities (WASAs). In October 2008, KCC transferred all human resources, physical assets, and financial accounts from its water works division to the newly formed KWASA, under the Local Government Division of the Ministry of Local Government, Rural Development, and Co-operatives.

ADB Initiates Support for Khulna City

The government and ADB recognized that the scope of investments needed in Khulna City's water supply and sanitation sectors would need to be significant in order to be truly transformative and sustainable. Fortunately, the timing of KWASA's establishment in 2008 set in motion ADB's entry to investing in Khulna City. In the same year of KWASA's establishment, ADB approved in December 2008 its first technical assistance (TA) to support the establishment of KWASA. The $225,000 TA supported a host of institution-strengthening initiatives to get KWASA off to a strong corporate start which included

- a diagnostic analysis of the city's water problems;
- an institutional capacity assessment of KWASA;
- a willingness-to-pay survey;
- a financial assessment of KWASA's operations and preparation of the opening balance of financial statements; and
- the development of corporate management systems, such as computerized accounting, payroll, human resources, and inventory management systems.

This work informed the next 10 years of capacity building for KWASA, which continues today under the latest approved ADB investment in the development of sewerage systems (Box 1).

Also in December 2008, ADB approved a second TA ($720,000) from the Climate Change Fund to study the city's regional hydrometeorology, urban planning process (plans and policies versus actual practices), and the city's socioeconomic profile to simulate models of climate change and identify climate adaptation strategies.

[14] Dhaka WASA would be the investment territory of ADB (for water supply) and the World Bank (for sewerage). Chattogram WASA would be the focus of the World Bank and the Japan International Cooperation Agency (JICA). The Danish International Development Agency and the Government of the Republic of Korea also signed the partnership framework.

Box 1: Transforming the Khulna Water Supply and Sewerage Authority

When the Asian Development Bank (ADB)-supported Khulna Water Supply Project (KWSP) was just getting underway in 2011, the Khulna Water Supply and Sewerage Authority (KWASA) was a new entity with inadequate staff.

"KWASA had such low capacity in the beginning that it really had no place to go but up—to develop and improve," said Rafiqul Islam, former ADB senior urban project officer.

The Government of Bangladesh established KWASA in March 2008, the third water supply and sewerage authority (WASA) in the country after Dhaka and Chattogram WASAs. Before KWASA's establishment, Khulna City Corporation (KCC) was responsible for water supply in Khulna City. To begin making KWASA operational, KCC transferred its staff to KWASA.

"As the first managing director of KWASA, I had to personally do things I hadn't done before and I did not have much logistical support, especially when this project started," said Mohammad Abdullah, who has been the managing director of KWASA since it was established. "We also did not have senior engineers for a long time. For years and years, I worked on holidays and days-off to get work done." Abdullah said he prioritized hiring engineers to operate the existing system at that time (before KWSP started). He recruited junior, mid-level, and senior engineers to provide training and career track within KWASA.

Most of the staff in KCC's water works division had been reluctant about their transfer to KWASA, Islam recalls. There were no systems in place or staff experience of working together. Abdullah agreed, "The new staff hesitated over KWASA because we were such a new organization. We had no track record or reputation. But KWASA proved itself to new staff by investing in them with relevant and intensive training programs. They spent time in the field to understand the system being built, which was the system they were representing."

ADB provided KWASA with its technical assistance within months of its establishment. The KWSP provided the most substantial support for establishing new administrative and management systems, a corporate business plan, and customized trainings. As an institution, KWASA built its capacity for more responsive customer relations and efficient billing and collection and is in its second year of full operation and maintenance of the new system (the surface water treatment plant, pumps, transmission mains, and distribution networks).

Project Director Kamaluddin Ahmed said of KWASA's transformations, "Staff know how to do the work of KWASA now. And they do it confidently. They have motivation."

Source: Authors.

The TA's findings helped inform the design of the KWSP, as well as identified priority recommendations for future ADB investments and government policies.[15]

ADB approved a third TA for $800,000 in November 2009 to continue the institutional development program of KWASA, conduct a groundwater assessment, and prepare a project proposal for ADB financing, which became the KWSP. The substantial technical, operational, and financial scope of the KWSP and with a newly established entity such as KWASA presented some risks. During conceptualization of the KWSP, JICA expressed interest to cofinance the project with ADB.

[15] ADB. 2010. *Technical Assistance to Bangladesh for Strengthening Resilience of the Water Sector in Khulna to Climate Change.* Manila. To read about the results of this technical assistance, see: ADB. 2011. *Adapting to Climate Change: Strengthening the Resilience of Water Sector Infrastructure in Khulna, Bangladesh.* Manila.

The ADB team leader for project preparation was Masayuki Tachiiri, now the director of the Strategy, Policy, and Business Process Division of ADB's Strategy, Policy, and Partnerships Department. He came to the project from having previously worked with JICA not as an engineer but an institutional development and governance expert. "We really tried through this project to help KWASA develop into an independent, professional organization," Tachiiri said. "It was this project that really put KWASA to work on its institutional development."

JICA immediately fielded a feasibility study team to augment previous studies conducted by the government, KWASA, and ADB. The feasibility study identified options for the development of water sources, water supply system, and service delivery. The design decisions were based on an analysis of projected population growth, current and future water demand, and options for water sources (see Appendixes 3–5 for a more detailed discussion of the studies and analysis that went into key aspects of the project).

"With JICA being the financing partner, ADB invested confidently in what became a large but much needed intervention for Khulna City and worked with KWASA, a newly established water utility," said Elma Morsheda, ADB infrastructure specialist, who led the project team through much of the implementation stages. "We developed a very good partnership with JICA."

Designing from Strategy

The work on water demand projections, groundwater assessments, and surface water quality studies helped the project development partners formulate a policy for sustainable water resource development, a crucial piece of groundwork for designing the KWSP. The JICA and ADB teams forecast a need for an additional 110,000 m^3/day from surface water to meet 2025 demand. This would require a new water source, though KWASA would continue to use groundwater but limit its extraction to the sustainability threshold. In assessing the technology and materials for designing the new system, JICA recommended conventional approaches to avoid costly desalination technologies and high operation and maintenance (O&M) costs.

One in 10,000. Shahida Begum, 28, and her family are one of 10,000 low-income community households to gain first-time access to 24/7 treated surface water through community water connections. The ADB-supported Khulna Water Supply Project provides low-income areas, such as Rupsha slum where Begum lives, with community water taps that are managed and paid for by water user groups. Begum said the convenience of having 24/7, clean water has saved her time and money that she puts to better use on her clothing business.

Upstream system investments. The Khulna Water Supply Project supported the construction of upstream infrastructure—surface water intake facility, raw water transmission main, and surface water treatment plant—as well as downstream network expansion and metered water connections.

SOLUTIONS

AN INTENSE STUDY OF OPTIONS INFORM THE DESIGN

The solution to Khulna City's water dilemma needed an overhaul of the entire system, which resulted in the KWSP cofinanced by ADB and JICA. Khulna City needed a new surface water source to alleviate its over-reliance on groundwater, a surface water treatment plant, transmission mains, citywide piped networks, and metered connections for every property or household, as well as necessary auxiliary assets (such as pumping stations, overhead reservoirs, etc.) and the information technology and management systems for modern operation. The KWASA staff would also need continuous training in technical, business, and administrative fields.

The KWSP was designed for three outputs: (i) augmented and sustainably managed water supply, (ii) extended and efficiently managed distribution network, and (iii) a professional and sustainable corporate management of KWASA. By overhauling the entire water supply system and strengthening the capacity of KWASA, the KWSP aimed to provide expanded and reliable water supply services to the residents in Khulna City. Rafiqul Islam, former ADB senior urban project officer who was part of ADB's administration team for 2 years of the project, said, "The KWSP was a big challenge—to build a utility and entire system from nothing—and not just a challenge for the government. It was also a challenge for ADB, too. It was a very successful implementation, though."

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Technical Solutions

JICA provided financing and project administration support for the construction of the "upstream" infrastructure: the construction of surface water intake facility, raw water transmission main, and surface water treatment plant with impounding reservoir. ADB's financing supported the establishment of the "downstream" infrastructure focusing on a distribution system: clear water transmission main for conveying the treated surface water to distribution reservoirs, overhead tanks, new and rehabilitated piped networks, pumps, valves, and other equipment. ADB also financed the installation of a supervisory control and data acquisition (SCADA) system and other technologies to enable a smart water management system. The distribution system was designed to ensure safe and proper water pressure for hourly demand variations, simple yet effective O&M, and to protect treated water from pollution and changes in water quality.

The Source: Ruling Out Groundwater

By studying the viability of groundwater and surface water, the project development partners determined how KWSP could most economically and sustainably meet projected water demand given the city's ecological limitations with groundwater and challenges with saline intrusion (see Appendix 3 for data on demand analysis). Based on current and forecast population growth for Khulna City, JICA confirmed that the city's reliance on groundwater could not meet future water demand. The city, through the KWSP, needed to develop a suitable surface water source.

Ruling out further groundwater extraction. Multiple studies over the years had proven that groundwater resources in Khulna City would not be able to support future demand and that surface water sources are scarce because of salinity intrusion. In 2005, a Local Government Engineering Department study of potential water supply sources in and around Khulna City showed that Bhairab River is not a viable resource because of high mineralization or turbidity levels that affect water quality as far as 35 km upstream of the city and for most of the year.[16] Any viable surface water resources would likely be distant from the city center.

In 2009, ADB supported a groundwater assessment as part of its TA to KWASA for preparing the KWSP. The study found that aquifers are productive, but salinity and poor quality from pumping were two major constraints to increasing extraction. JICA's feasibility study team and ADB's project design team agreed with the Local Government Engineering Department and KWASA that current groundwater extraction rates could be maintained but without any future extensive development. This meant that any new water source development must come from surface water.

Developing a surface water source. JICA conducted three water quality assessments of 12 river sites from 2009 to 2010 and monitored daily salinity levels during the hot, dry months (March and April) when salinity levels are likely to be highest (see Appendix 3 for a map of the sites and information on indicators).

The JICA study team also noted that the choice of the surface water resource had to consider three additional factors:

- Chloride higher than the Bangladesh standards of 1,000 milligrams per liter (mg/L) were observed in one of the studied rivers, the Rupsa River, for 4–7 months of the year.
- Three potential sites (Mollarhat, Chapali Ghat, and Haridaspur) were located quite far for economically ideal water transmission—58 km to 77 km away from Khulna City and these sites also experienced some higher chloride days.
- To counter the salinity levels, either a salinity-free water reservoir or saline water treatment process would be needed.

The JICA team found that all but three of the 12 sites had high levels of turbidity, biochemical oxygen demand, chemical oxygen demand, total suspended solids, etc., along with high levels of iron and manganese. The team narrowed the potential sites down to three (in Mollarhat, Phultala, and Khulna).

Heavy metals at all three locations were below the government's standards, but Mollarhat had a clearly better quality of water in terms of turbidity, chemical oxygen demand, and biological oxygen demand. Its higher chloride days during the dry season could be addressed by mixing high-chloride water with low-chloride water stored in an impounding reservoir during the rainy season. Mollarhat also showed lower levels of arsenic, zinc, and manganese.

[16] Government of Bangladesh, Local Government Engineering Department. 2005. *Final Project Report: Groundwater Resources and Hydro-Geological Investigations in and around Khulna City/Municipal Services.* Dhaka.

Although the water assessment results were not ideal, the JICA study team found that chemical and biological oxygen demand seemed to come from particulate substances in the water, allowing for a normal purification process to adequately treat the river water. The JICA study team concluded that the Mollarhat site was the most suitable surface water resource for KWASA to develop.

The Intake

Out of 12 water quality assessment sites, the JICA feasibility study team further studied eight sites with relatively good water quality to determine the intake sites. The team used a variety of technical, social, environmental, and pollution factors of potential impacts to select the best intake location among eight possible sites. See Appendix 4 for the comparative data that the team used to determine its ideal intake site.

According to the assessments, the best option for an intake site was from the Madhumati River at Mollarhat. It measured the most ideal river flow, water quantity, and distance to the proposed surface water treatment plant. It also posted the lowest construction costs. The study team also tested the chloride concentration from March to July in 2010 and found that chloride concentration exceeded environmental quality standards for 15 days in April (5–20), and continuously decreased after that period. The team recommended the construction of an impounding reservoir, to store low-chloride water for mixing and diluting the river's high-chloride water during summer, to achieve an acceptable quality.

The selected intake site (from the Madhumati River at Mollarhat) is located 58 km northeast of Khulna City, a costly distance to build and transfer bulk water, yet the closer alternatives recorded much higher salinity levels that would require expensive desalinization treatment and high O&M costs (Appendixes 3–4 provide details relevant to the source selection and intake site selection).

The intake facilities produce 129,600 m^3/day of surface water,[17] thus reducing Khulna City's reliance on groundwater to a maximum of 50,000 m^3/day upon project completion. The new surface water production also enabled KWASA to limit the maximum drawdown to a sustainable level of 6 meters (m). The intake facilities also included three pumps and a 1,500-kilovolt-ampere (kVA) substation for dedicated power supply.

Moving Raw Water

A raw water transmission main was constructed to transport surface water from the intake facility to the surface water treatment plant, which is 33 km away.[18] The route required 26 pipe bridges to cross rivers, channels, and middle-size box culverts.

[17] The intake is sited 58 km northeast of Khulna City, along the banks of the Madhumati River adjacent to Mollarhat Bridge in Bagherat.

[18] The raw water transmission main is constructed from ductile iron (1,400 millimeters in diameter) and laid 1.5 to 2.0 m deep from the intake structure to the treatment plant, which is sited in Samanto Sena.

Farther but more cost effective. Although a distant 58 kilometers northeast of Khulna City, the Madhumati River at Mollarhat enabled the Khulna Water Supply and Sewerage Authority to avoid costly desalination treatment on nearer water sources.

A Reserve for Drier Days

An impounding reservoir was constructed to ensure sustainable water supply during the dry season months of March, April, and May, when the river flow is lean and chloride concentration is high (beyond the environmental quality standard of 1,000 mg/L for 45 days of the dry season). During the dry season, when chloride level gets higher, the high-chloride raw surface water is mixed with and diluted by the low-salinity water in the impounding reservoir before being sent to the surface water treatment plant. The impounding reservoir maintains a 7-day supply with a reserve capacity of 775,000 m^3; the reserve amount may be extended when needed by blending the reserve with intake water for quality blended water.

From Surface to Treatment

The surface water treatment plant generates 110,000 m^3/day to help meet the 2025 demand. The new surface water treatment plant conforms to the Bangladesh government's Environment Conservation Rules (1997); and, being a coastal area, uses a chlorine concentration of 1,000 mg/L.[19] The surface water treatment plant is currently being operated on an automated control system and includes a sufficient power supply with a backup facility of 250 kilowatt (kW) solar system and a sludge drying facility.

[19] Considering the raw water quality, the JICA feasibility study team proposed a "Coagulation–Sedimentation + Rapid Filter Process" as the water treatment method considering lower construction cost, high turbidity of water, evaporated residue, and large water flow.

Deep tube well testing. Although the Khulna Water Supply and Sewerage Authority (KWASA) was able to reduce its total groundwater extraction to less than 50,000 m^3/day (a sustainable limit), it still tests the groundwater quality to ensure safety standards. The Khulna Water Supply Project supported the establishment of the laboratory and training programs for the concerned KWASA staff.

Testing to Be Quality-Sure

The surface water treatment plant also includes a state-of-the-art laboratory for continuous water quality monitoring and testing of deep production wells to ensure compliance with international and national standards. JICA supported the long-term training of KWASA laboratory personnel on equipment operation and laboratory management.

The Long Haul

The KWSP supported the construction of a 45.47 km long transmission main to deliver treated surface water to seven new distribution reservoirs and 10 new overhead tanks with pumping stations that were also constructed throughout the city as part of the project.[20] The transmission main also connects to deep tube wells, and two new electric generators provide emergency power supply.

[20] Of the nearly 65.47 km long transmission main, 8.5 km delivered treated water to the 10 overhead tanks and 1.5 km to connect to deep tube wells.

A first for surface water. The Khulna Water Supply Project provided Khulna City with its first surface water intake facilities and treatment plant, which produced 110,000 m^3/day. In July 2019, more than 40,000 connections across the city received treated, clean surface water for the first time.

The transmission route needed to cross the Rupsa River from beneath the riverbed, which proved to be an exceptional challenge for the project and a valuable lesson. "It was a very new technical challenge for the entire engineering team—from the contractor's side and KWASA's," Ghosh said. The river crossing ensured the most affordable and efficient route for the transmission main, given that it was coming such a long distance from the treatment plant to the city distribution network. The river crossing measured 685 m long. The project design called for the horizontal directional drilling method at 14–15 m beneath the riverbed to lay the water transmission main. This had never been done in the water sector in Bangladesh.

Before commencing the construction, the contractor assessed the site against the design and concluded that the angle of the pipe entering from the road to the riverbed may not be appropriate and could result in construction failure. The contractor proposed a more flattened (horizontal) angle to connect the ground level to the riverbed level using a mild steel pipe to avoid construction risks and ensure long-term durability. KWASA and ADB agreed that the contractor's newly proposed designs would be safer, more durable (particularly the pipe joints), and would reduce the head loss. Although the new pipe inclination increased the cost of that particular piece of work, it did not affect the overall contract price.

"In the end, the contractor's suggestion was better," Islam said. "That shows the quality of the contractor. They did not blindly follow the designs. They studied them and came up with a better way." KWASA and ADB project staff also praised the contractor for closely studying the designs to ensure they understood and could execute the designs as-is or propose a more efficient and feasible approach.

Zoning the Distribution Network

The KWASA service area covers all 31 administrative wards in Khulna City. To expand the distribution network with technical, financial, and social integrity, the KWSP applied the "district metered area" (DMA) approach, which had been successfully championed by Dhaka WASA[21] and adopted by water supply operators throughout South Asia.

The DMA approach divides the water supply network into small hydrologically independent service areas for more precise operation, maintenance, and monitoring of contaminants, pressure, leakage, theft, and damage. The primary criterion for the establishment of a DMA is that the distribution network for the metered area can be easily isolated through control valves and other such mechanisms. Bulk meters are installed to monitor the total volume of water supplied to the demarcated area. All connections within the area must be outfitted with proper metered connections for domestic and non-domestic users.

In Khulna City, the water supply area is divided into 10 zones and 66 DMAs. The average number of connections per DMA is 680. Each zone has closed "boundaries" with electromagnetic flow meters at each end of the zone monitoring water flow in real time in order to measure wholesale consumption and detect leaks and other water losses.[22] "Until 2014, nobody was measuring water volume," said Mohammad Abdullah, KWASA managing director. The measurements are stored in a flow logger and transmitted to the central control room inside KWASA headquarters using mobile phones.

How KWASA divided the coverage area into 10 zones is based on studies by both the JICA feasibility study team and ADB's project preparation team. Each team compared distribution options, dividing KWASA's service area into three to 10 distribution zones. KWASA opted for the 10-zone scheme for the DMAs. Ten zones offered the most significant reduction in pipe size of the transmission main, reduced the delivery pipeline length from the deep wells to the reservoirs (which minimizes the required booster pumping station), and required the least capital and operating costs.

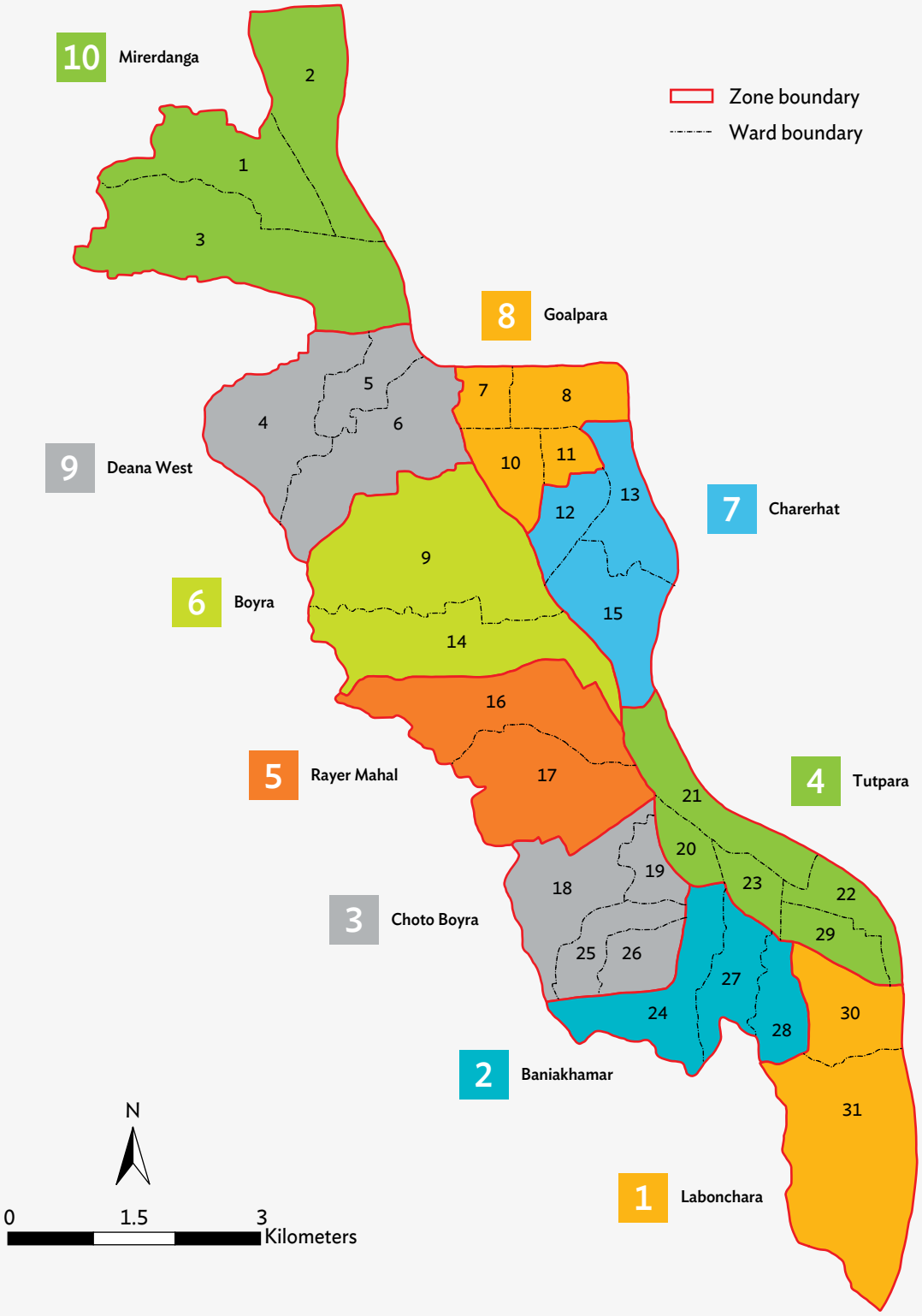
Strategic Storage

Seven reservoirs are centrally located or near to each of the 10 distribution zones (Appendix 5) and hold 12 hours of storage, which is adequate for the time-based fluctuations in demand and for emergency situations. The reservoirs are designed to be durable enough to be earthquake-proof and leakproof. Ten overhead tanks are installed on the ground and regulate flow and pressure.

[21] For more information on Dhaka's well-established and pioneering success with the DMA approach and as a study destination for other South Asian urban water utilities, see 2016. ADB. *Dhaka Water Services Turnaround: How Dhaka is connecting slums, saving water, raising revenues, and becoming one of South Asia's best public water utilities.* Manila.

[22] The distribution network uses three types of DMAs: single inlet, multiple inlets, and flowing.

Map 2: Location of 10 Zones for Khulna Water Supply System



Source: Khulna Water Supply and Sewerage Authority.

Networking the Urban Interior

The KWSP extended the piped water supply network from less than 20% to 65% of the KWASA coverage area. The project installed 662.59 km of distribution pipelines (this is excluding the 45.47 km of transmission main). The network consists of four categories of distribution pipelines: trunk pipe, main pipe, branch pipe, and small distribution pipes. The trunk pipes were installed from the overhead tanks to the water supply zones. The main pipes connect the central areas of the distribution zone, while the branch pipes distribute water within the zone interiors. Each of the 10 zones is connected to ensure water supply in an emergency. As a result of the DMA approach and new distribution infrastructure, water leakage has been reduced from 36% to between 10% and 20%.[23]

Metered Connections

The vast majority of the 40,000 connections were first-time household connections, which benefited an estimated 800,000 people. Another estimated 200,000 previously connected residents received new (replacement) connections. As part of the 40,000 new connections, the KWSP supported 18 low-income communities with 250 metered connections to supply treated water to the shared community taps.[24] A water user group (WUG) was formed for each community connection to maintain the tap, report issues to KWASA, and collect charges from the households for paying the monthly bill. Women make up 45% of the WUG members and 45% of leadership positions.

The KWSP exceeded its original targets (Table 5). The project connected 65% of households to piped water supply compared to its target of 62.3%; 26.5% of households continue to use tube well water rather than the target of 27.3%; and 8.5% of the households use water from the other sources like ponds and buying, close to the target of 8%.[25]

Table 5: Original Targets of Khulna Water Supply Project

Water Access Points	Pre-Project (2010)	Post-Project (2019)
KWASA piped water supply system	Less than 20%	62.3%
Piped water	18%	62.3%
Unaccounted (illegal connections, etc.)	6%	n/a
KWASA hand pump tube wells	34.1%	10.4%
Private tube wells	34.1%	27.3%
Others (pond, river, tanker, etc.)	8%	8%

KWASA = Khulna Water Supply and Sewerage Authority, n/a = not applicable.

Sources: ADB. 2011. *Project Preparatory Technical Assistance Final Report for Preparing the Khulna Water Supply Project.* Consultant's report. Manila (TA 7385-BAN) (see Appendix 5: Social Assessment Report); ADB. 2020. *Completion Report: Khulna Water Supply Project in Bangladesh.* Manila; ADB. 2016. *Khulna WASA Business Plan 2016 to 2020*. Consultant's report. Manila (TA 7385-BAN).

[23] ADB. 2020. *Completion Report: Khulna Water Supply Project in Bangladesh.* Manila.

[24] Government of Bangladesh, Khulna Water Supply and Sewerage Authority. 2020. *Project Completion Report: Khulna Water Supply Project (for the JICA loan components).* Khulna.

[25] ADB. 2020. *Technical Assistance Completion Report: Supporting the Khulna Water Supply Project in Bangladesh.* Manila.

Table 6: Piped Water Supply in Khulna City

Connection Type	Pre-Project (2010)	Actual (2019)
Non-Domestic Connections	523	533
Legal	385	523
Illegal	138	0
First-time connections	n/a	10
Domestic Connections	14,059	40,000
Legal domestic connections	11,853	14,059
Illegal domestic connections	2,206	0
First-time connections	n/a	25,941

n/a = not applicable.

Sources: ADB. 2011. *Project Preparatory Technical Assistance Final Report for Preparing the Khulna Water Supply Project.* Consultant's report. Manila (TA 7385-BAN) (see Appendix 5: Social Assessment Report); ADB. 2020. *Completion Report: Khulna Water Supply Project in Bangladesh.* Manila.

Table 6 provides detailed data on the 40,000 new domestic connections and 533 non-domestic connections installed by KWSP. Each domestic connection actually services more than one household. The congestion and awkward location of homes and streets in Khulna City make individual household connections difficult. An average of 4.5 households share one domestic meter connection, except in the case of the 250 metered community connections that supply water to shared tap stands that are managed by the WUGs established by the project. About 1 million people or 190,000 households are benefiting from the new domestic connections provided by the project.

Financial Solutions

A unique set of consultants assisted in the corporatization of KWASA by updating the corporate business plan (CBP), which is critical to KWASA's long-term success (Box 2). The main objective of the CBP was to provide a road map for achieving financial and technical targets within a particular time frame to make KWASA sustainable. At the inception of KWSP, KWASA had a 5-year CBP that needed further development. It needed to incorporate debt servicing from KWSP and a 20-year planning horizon. The project consultants worked with KWASA to strengthen the CBP with three key components: (i) capital investment plan, (ii) financial plan, and (iii) human resource development plan (see next section on Institutional Solutions). KWASA is still developing its 20-year planning horizon. The consultants worked with KWASA for much of the project implementation's 9 years to continuously improve the CBP.

Capital Investment Plan

The plan is largely focused on the expected outputs of KWSP, but also included smaller government-funded projects, such as rehabilitation of deep tube wells and network expansion. The capital investment plan needed to include KWSP, but also look beyond it at other large infrastructure projects. The TA that accompanied the loan for the KWSP also supported the recruitment of a consulting firm to conduct a feasibility study and formulate a master plan on wastewater management for Khulna City. The study and the master plan informed the preparation of ADB's newest project in Khulna City, a $160 million loan to establish the city's first sewerage system, which is currently being implemented by KWASA.

Box 2: The Long Road to an Acceptable, Viable Corporate Business Plan

Project consultants were responsible for supporting the Khulna Water Supply and Sewerage Authority (KWASA) in developing the utility's corporate business plan, which was under development for nearly the entire project duration. "The business plan is a key to the sustainability of the system, so it had to be done right," said Sudhir Kumar Ghosh, project management consultant.

A first draft of the plan was proposed in 2014. "The first draft was simply not acceptable," said Elma Morsheda, Asian Development Bank infrastructure specialist who led the team through the design and most of the implementation. "Everybody involved in the business plan needed to understand that KWASA has to repay the loan to the government." Yet, the initial business plan was missing key elements (or those elements were underdeveloped), and it was a significant task to bring the plan to an acceptable draft that addressed repayment, tariffs, billing, revised organogram, customer and/or population projections, operation and maintenance financing, etc.

For the duration of the Khulna Water Supply Project, from 2013 to 2019, the business plan was under continuous revision due to prolonged consultations and negotiations between the government and KWASA. In the end, Morsheda said, "We gave the government a vision of how to make KWASA sustainable. It is now a complete plan for developing a self-sustaining utility."

Source: Authors.

Financial Plan

KWASA's financial condition at the outset of the KWSP was weak because of a lack of revenues to sustain operations. KWASA had a small and illusive customer base and an artificially low water tariff. Less than 20% of the households was covered by the old system. Only 84% of households connected were billed and from those KWASA only successfully collected from 80%. What was collected was not based on actual usage (a volumetric tariff) but a monthly flat rate because connections were not metered. Multiple households often shared a single connection, and many connections were illegal. Table 7 summarizes the baseline for KWASA's performance on billing and collection.

Table 7: Billing and Collection Efficiencies in Khulna City

Indicators	Pre-Project (2010)	Post-Project (2019)
Total number of metered connections	–	40,000
Connections billed	84%	100%
Connections collected	80%	95%
Ratio of operating expenses to revenues	4.17	2.15

Source: ADB. 2011. *Preparing the Khulna Water Supply Project.* Consultant's report. Manila (TA 7385-BAN).

Metering and connection costs. Equipping every connection with a meter was essential for KWASA's financial recovery, stability, and sustainability. Prior to the KWSP, the small percentage of KWASA customers who received a bill only paid a monthly flat rate regardless of usage. KWASA had no way of accurately measuring the usage because connections were not metered. Introducing meters also incurred new O&M costs.

Metered, billed, and paid. Prior to the Khulna Water Supply Project, the Khulna Water Supply and Sewerage Authority had no way of measuring usage because the connections were not metered. Households paid a monthly flat rate of about Tk68 per month, of which it only collected on 80% of billed users. Now, water usage is billed at a volumetric tariff currently set at Tk6.91/m^3 and has a 95% collection rate.

Tariff reforms. The centerpiece of the updated financial plan was a phased volumetric tariff structure that would put KWASA on the trajectory to full cost recovery. The introduction of household meters was KWASA's opportunity to begin raising awareness about water tariffs. Consumers could be assured through meters that they would be paying for only what they use. The meters were also real and symbolic of life getting better in Khulna.

The current volumetric tariff is Tk6.91/m^3 and the tariff collection rate has improved to 95%. The tariff structure does not utilize an increasing block tariff (higher usage, higher tariff per unit) to avoid adversely affecting shared connections in low-income communities. The financial plan also calls for KWASA to begin charging for tube well water Tk3.8/m^3 for domestic connections and Tk9.0/m^3 for non-domestic connections.[26] Prior to the KWSP, according to a household consumer study by ADB, households connected to piped water generally consumed an average of 20.6 m^3/month for the flat-rate cost of Tk68 per month. The survey showed that a high percentage of extreme poor and above-poor were willing to pay up to Tk200 per month.

With increased costs to customers, KWASA needed to prepare the public to pay for what it had historically either got for free or at very little expense. "KCC did not have a history with water tariffs and people believed it was government's responsibility to provide safe drinking water," said Mohammad Abdullah, KWASA's managing director. "So, there was a reluctance to paying for water in the beginning." Water tariffs proved to be something residents were willing to start paying for, though the tariff is scheduled to increase 5% annually until 2025 when KWASA is expected to reach a level that fully recovers the cost of providing the service.

[26] JICA. 2011. *Final Report: Feasibility Study for Khulna Water Supply Project in Bangladesh.* Tokyo.

Connection, not conflict. In Rupsha slum, Kajol Begum (center), 29, and her neighbors received their first-time community water connection to the Khulna Water Supply and Sewerage Authority. The connection has brought the women together rather than apart, fighting in long queues at the old tube well that produced little water that was highly salinated.

Impact Story 1

With First-Time Community Water Connection Comes Peace and Confidence

Rupsha slum, along the Rupsa River, is one of the biggest and oldest slums of Khulna City. The Rupsa River is an essential water resource to the community. Aside from providing an alternative water source to the tube wells, however poor the river water quality, the Rupsa River provides livelihoods—fish processing factories and water vessel landing stations for off-boarding fish, salt, and building materials. The slum residents are involved in a diverse income range such as rickshaw pullers and wage labor in the water vessel landing station, fish processing plants, and construction.

Kajol Begum, 29, has lived with her husband and in-laws in Rupsha slum for 18 years. Her husband's family moved to the slum 35 years ago. Their house is commonly known as Hanif Sekher Bari, where 12 families (about 50 people) live together. Some families occupy one room, and others have two rooms. They do their daily household chores in the narrow, shared yard.

Begum used to spend her entire day near the tube wall. The five members of her household needed at least 20 buckets of water for daily use, which took Begum 3 hours of walking back and forth from the tube wall every day.

In 2019, as part of the Khulna Water Supply Project, the Khulna Water Supply and Sewerage Authority (KWASA) installed a shared community tap stand to deliver 24/7 treated surface water to Begum's community.

"For the first time in my life, I stopped worrying about water," Begum said. "Now I have time to help my daughter with her studies. I no longer have aches and pain from pumping tube wells all day long."

Begum remembers frequent doctor visits when her daughter and elderly mother-in-law were sick from the poor water quality. To keep up with the medical fees and bills, Begum relied on high-interest loans. "In the past, we paid thousands of takas to the doctor. Now we save that money for our children's education," Begum said. As a result, she's also able to take better care of herself, recalling when she was too exhausted to shower after long days of waiting and fighting in the queue for a turn to pump water.

Relations between tenants have improved drastically since receiving the KWASA connection. "Before we have this water connection, everyday women quarreled over simple things," Begum said over the water stress levels in the community. "The abuse at home and violence was alarming. Now, we have peace."

continued on next page

Impact Story 1 *continued*

Begum was elected the leader of the local water user group (about 12 properties) that looks after the maintenance of the tap and meter. Begum collects payment from the user group for the monthly water bill, about Tk100 monthly. "I want to support other group members," Begum said. "I have gained a responsible position in this area and have become confident than ever before."

With more free time available to her now, Begum earns from tailoring jobs in her community.

Source: Asian Development Bank.

Institutional Solutions

A standard component of ADB loans is to provide support for capacity development of implementing agencies and other project stakeholders in advance and during project implementation. As a new corporate entity, KWASA needed to develop its technical and financial capacity as an institution. KWASA did not have adequate systems for procurement, financial management, and social safeguards for resettlement and environmental mitigation, as well as other operational areas such as customer service, billing and collection, and public relations. The KWSP was KWASA's first experience in managing a large and externally financed project. KWASA has called it a "mega project," and its staff needed a comprehensive and systematic program to ensure they were prepared for the O&M of the physical infrastructure as well as the new business systems and processes that KWSP was supporting.

The KWSP included a $700,000 TA to support KWASA's implementation of the project but also institutional capacity development of KWASA through the development of systems and its staff through training. The TA enabled the recruitment of a nongovernment organization (NGO) to assist KWASA in implementing the resettlement plans, while seven consultants assisted and trained the project management unit on procurement, financial management, and detailed designs.

A Proper Headquarters

KWASA was established as a new entity in March 2008, 4 years prior to the commencement of the KWSP, and ADB financed the construction of a dedicated 6-story headquarters and two 2-story zonal offices for KWASA. As an autonomous entity from KCC, the office buildings contributed to the professional administrative and customer service functions of KWASA, which were also a major focus of KWSP. KWASA headquarters houses a central control room that receives remote monitoring data from across the system through wireless connections and is technologically capable of adjusting operations.

Human Resource Development Plan

The government gave KWASA full responsibility for Khulna's water supply and sewerage services. KWASA is governed by a 13-member board and its executive management includes a managing director and two deputy managing directors. KWASA's organogram has evolved over the years to align with the demands of new capital investment plans, but it has yet to be approved by the government.

Organogram. KWASA's organogram has evolved over its first decade of operation, as the needs of the system it inherited and the system it has been building became clearer. KWASA's structure has grown more sophisticated from its initial two divisions (technical division and financial and administrative division) into four divisions: O&M, Planning and Development, Finance, and Administration. This organogram indicates the total human resource consists of 553 staff in 95 positions to reflect the needs of a fully functioning and at-full capacity KWASA system. KWASA currently has 275 approved staff.

KWASA, ADB, and JICA anticipated in their planning that many technological innovations, computerization, and other related advancements would need to be incorporated into KWASA over time. The introduction of these technologies will need to be reflected in the structure of the organization and the staff that are to be employed by KWASA. The KWSP corporate management consultants worked with KWASA to update job descriptions according to the revised organogram. Every staff member needs to know his or her role, responsibilities, and to whom he or she is accountable. Institution-wide clarity creates an environment and system that is easier to manage. Employees can also be more effective in performing their jobs when they understand the work (scope and expectations) and the appropriate authority of their position within the organization.

KWASA needs to function as a dynamic service provider, expanding into new technical areas to provide increasingly better services. The project consultants identified the future need for several new subdepartments and technical specialists, which are not included in the current organogram or business plan:

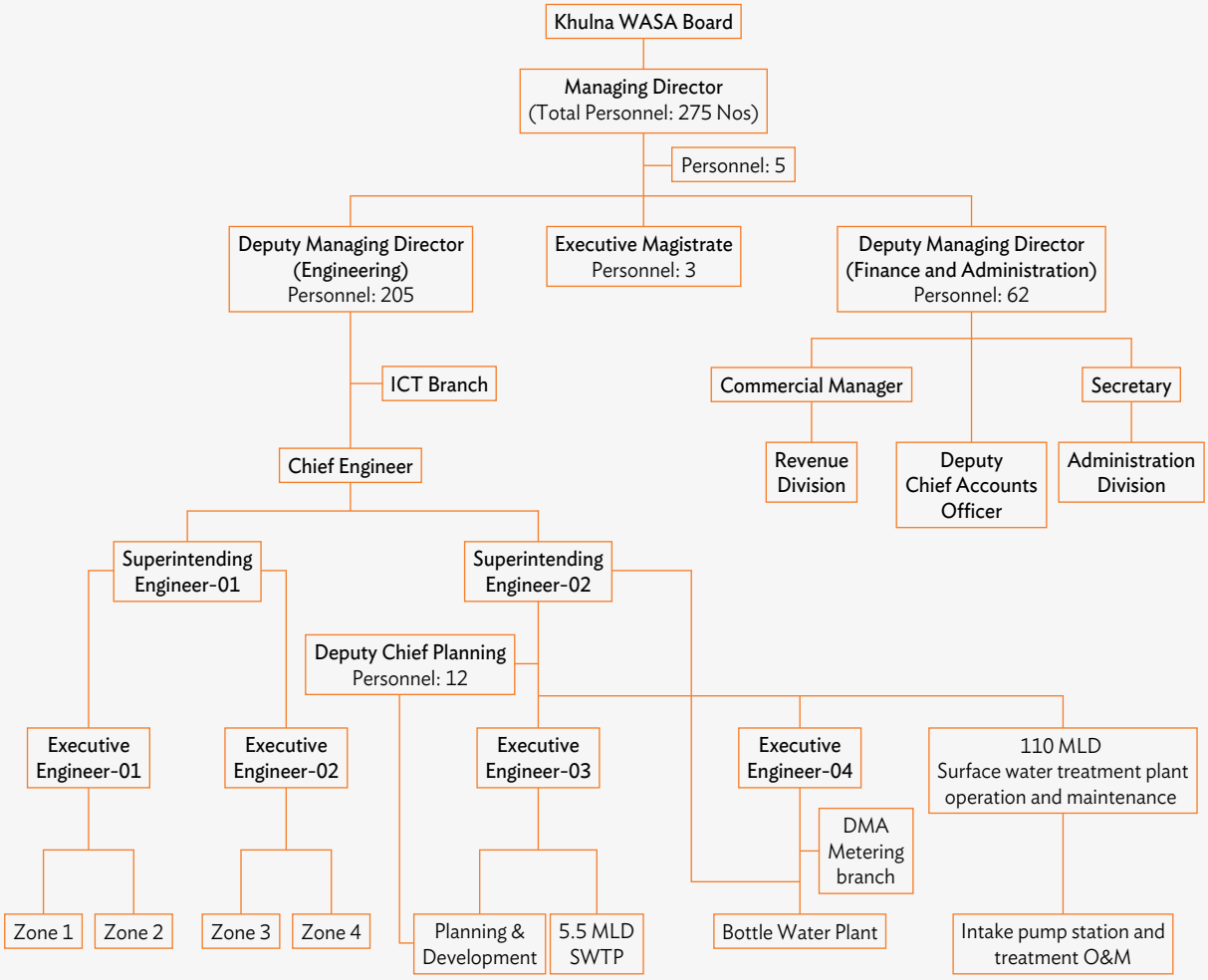
- water quality laboratory chemist and/or microbiologist,
- production well specialist,
- production tube-well monitoring,
- geographic information system mapping expert for a wide variety of inputs, and
- meter superintendent and workshop-in-charge.

Training. ADB has been supporting KWASA's capacity development at institutional and personnel levels since it was established in March 2008. Over time, ADB's various TAs to support KWASA's development introduced greater scales of automation to much of KWASA's systems and business processes, including O&M, accounting, inventory, and billing. "Automation brings transparency and accountability. It reassures consumers, too," said Mohammad Abdullah, KWASA managing director.

The KWSP significantly expanded KWASA's operations, requiring staff skills and competencies to also expand. A training program was developed and implemented in line with project implementation. To contribute to the staff's understanding of KWASA's corporate culture and expectations, all KWASA staff were trained in office etiquette and manners. The KWSP supported 19 trainings in the fields of finance and accounting, geographic information systems, communications and community development, customer service, and water supply technology (for a detailed list of trainings, see Appendix 6).

Consultants reported that the most effective training method was "learning by doing." For the construction supervision and O&M staff, this meant on-the-job training in metering, calibration, and repairing meters.

Figure 3: Current KWASA Organogram



DMA = district metered area, ICT = information and communication technology, KWASA = Khulna Water Supply and Sewerage Authority, MLD = million liters per day, Nos = number of approved staff positions, O&M = operation and maintenance, SWTP = surface water treatment plant, WASA = water supply and sewerage authority.

Source: Khulna Water Supply and Sewerage Authority.

KWASA staff were integrated into the consultant's overall construction supervision team in line positions that were most appropriate to their experience. To ensure quality work, KWASA provided supervisory staff and a workforce for general O&M and assigned dedicated staff to the surface water treatment plant, where they worked with the contractor's technical personnel to learn the new systems.

Consultants worked alongside KWASA staff to prepare basic book account entries such as writing journal and debit vouchers, bank books, making bank reconciliation reports, etc. Consultants also worked with KWASA officials to prepare periodic reports, including annual financial reports. KWASA officials can now independently prepare annual financial reports, a remarkable outcome considering KWASA's baseline capacity. Training will continue during the implementation of ADB's latest investment in KWASA, a $160 million loan to establish the city's first sewerage system.

On duty. Md. Shahin Slam and Hafizur Islam, both operation and maintenance assistant managers, monitor the automated operating system for the water supply intake and treatment plant.

Social Solutions

The KWSP worked to relieve water-related social and economic burdens of low-income communities, and especially of women, by providing water connections that were more convenient and a water supply that was cleaner and more available. Women were far more likely than men to experience the household's burden of water security through hours of planning for water deliveries and multiple trips to and from tube wells and standpipes, where they spent more time waiting and in conflict with neighbors who were equally stressed for lack of water, time, and energy. The KWSP employed a number of strategies to ensure low-income and women benefited from the project. Low-income households headed by women were given special priority, connecting 6,500 household connections to these women.

Subsidized Connection Fee

The connection fee, if charged at the actual cost, would have been a major barrier for low-income households to connect to the new system, which would affect KWASA financially if few potential customers were connecting. The unit cost of a household service connection was about $135, a well-established impediment to customers' connections. To support 100% connection among eligible households, the KWSP absorbed the material costs of connecting users and offered a reduced low-cost connection fee for a limited time before the system was commissioned. The highly affordable and low-cost connection fee was also a strategy to ensure equitable access for low-income households. With subsidized connection fees, the poor were able to connect.

Box 3: Mentoring Partnerships Offer Support in Rolling Out Major Changes

In rolling out major changes under the Khulna Water Supply Project (KWSP), the Asian Development Bank (ADB) connected the Khulna Water Supply and Sewerage Authority (KWASA) to leading regional utilities and knowledge partners—demonstrating the value addition of ADB financing.

Operational mentors. ADB facilitated a partnership between KWASA and Maynilad Water Services, Incorporated (MWSI), a Philippine-based company with extensive experience in providing technical support to water utility operators. MWSI is the private water and wastewater service provider for 17 cities and municipalities situated in the western zone of the greater Metro Manila area. The Maynilad Water Academy has partnered with ADB's Water Operator Partnerships Program. KWASA and MWSI worked through remote consultations, exchange visits, and on-the-job training.

The KWASA–MWSI partnership focused on (i) district metered area (DMA) formation, (ii) data management and documentation of nonrevenue water (NRW monitoring), and (iii) adopting a more effective procedure for working with customers in the connection and servicing of meters. KWASA and MWSI worked together on metering about 9,000 service connections, forming three DMAs, using daily production logs and monthly consumption monitoring, and adopting a more effective procedure in customer service connection (reducing the customer connection runtime from 30 to 20 days). The cost of water meters (including the meter chambers) proved a contentious issue among low-income households. To quickly address this issue and avoid implementation delays, KWASA and MWSI worked out a plan for KWASA to initially cover the costs related to installing the meter chambers and recover the cost from customers on an installment basis.

SCADA support. ADB partnered with the Government of the Republic of Korea's globally renowned water supply service provider and training center, K-water, to provide field-based training on smart water management to KWASA's management, engineers, and technicians.[a] The KWSP has outfitted KWASA's operations with a supervisory control and data acquisition (SCADA) system that provides automated, real-time, end-to-end monitoring of reservoirs, overhead tanks, and all 66 DMAs. The piped network system is organized into 10 zones comprised of 66 DMAs to improve operation, maintenance, and monitoring on a smaller and more manageable scale.

The SCADA system generates reservoir and overhead tank capacity, pump flows, delivery pressure, valve status, and chlorine dosing, and transmits information to a control room inside KWASA headquarters. The flow within DMAs is also monitored by real-time readings that are stored in a flow logger and transmitted via mobile phone to the central control room. Alarms are programmed to pre-defined operating specifications and are triggered when measurements anywhere in the system are outside the normal daily range.

K-water experts trained KWASA staff on diagnostic methods for monitoring DMAs and detecting leakage. The training exercises demonstrated how to detect major network problems in the future. Together, K-water and KWASA technicians selected various measurement points in one specific DMA to measure for water flow, pressure, and quality analysis. The diagnosis methodology focused on the selection of measurement points, how to analyze the measurement results, and troubleshooting measures for resolving potential issues in case of changes in pressure and/or flow. KWASA engineers were trained to diagnose the DMAs in Khulna City by performing a similar process.

[a] ADB. 2015. *Technical Assistance for Promoting Smart Drinking Water Management in South Asian Cities.* Manila. https://www.adb.org/projects/49289-001/main.

Source: Authors.

Community-Based Connections and User Groups

In low-income communities, where individual household connections were not practical under the KWSP, the project provided 250 metered connections that supplied treated water to shared community taps stands, where multiple faucets could serve many households. Typically, the women in the household spent a daily average of 90 minutes fetching water, with poorer households spending as much as 120 minutes fetching water every day. The average daily time to fetch water was reduced to less than 20 minutes per day.

Safe water. Mothers reported that bathing with the former groundwater supply, which had high saline levels, caused rashes and children were often sick with diarrhea. The new treated surface water supply has brought relief to their health and medical expenses.

The project organized WUGs for each of the 250 community connections, providing an opportunity for women to have an equal chance at gaining leadership roles and understanding the new water supply system and ongoing maintenance issues. Each group selects a representative to act as group leader and collect the monthly billed amounts from household users. Women make up 45% of the WUG members and 45% of leadership positions.

Women-Focused Opportunities

The KWSP worked in a variety of ways to ensure women had equal access to project-related employment, learning opportunities, and decisions on connection points:

- A priority of the KWSP was to ensure that women would be given equal opportunities for employment with contractors, including construction. In total, almost 19% of person-days for construction were completed by female laborers. Contractors reported a high work ethic among women and were more inclined to promote jobs and female hiring in the future.
- Individual household connections were not always possible due to dense neighborhoods. In those cases, the KWSP implementation team worked with women in selecting the more convenient locations for new and improved community water points.
- Women were also the focus of awareness-raising events that focused on explaining water bills and tariffs, proper use of water, local water management, and both personal and communal health and hygiene practices.

Community water leader. In Rupsha slum, Kajol Begum, 29, and her family was one of the first households to receive a first-time community water connection to treated, 24/7 water supply. Begum is responsible for arranging monthly meetings with her water user group and collecting payments for the monthly water bill.

Impact Story 2

Shared Community Taps Brings Improved Health, Neighbor Relations, Prosperity

When Ambia Akter, 24, got married 4 years ago and moved to Khulna City's Rupsha slum, her household chore was to go back and forth to the nearest tube well to fetch water for the five members of her new household. From early morning to midday, she collected water that was not even fit for cooking or cleaning.

"We bathed with that water because we had no other options. The itching started immediately after taking a shower," Akter said. Excessive salination and hauling were the cause of some of the health issues in the community, while scarcity created social conflict.

"During my first pregnancy, I became sick," Akter said. "The only available water source was salty and dirty. Stomachaches were common."

The Asian Development Bank-supported Khulna Water Supply Project installed 250 metered connections for shared community taps in Khulna City's slums, the most difficult places to extend the network because of high population and structural density. The tap stands supply treated water from a new surface water source.

Akter's community, Hanif Sekher Bari at Rupsha slum, finally found some relief with the new community taps. Akter says she no longer suffers from the aches and pains from pumping a tube well for hours. She is now able to cook meals more quickly. The hostile relationship she experienced with a neighbor because of continuous conflict over water collection was emotionally painful for Akter, she said. But after gaining the 24/7 water connection, Akter said her relationship with her neighbor and others in the community has improved.

"For the first time in this area, women can sit in the evening and spend time with each other. Our bond has grown stronger, and we've become more supportive of each other. There is now no competition over water collection," Akter said.

Akter is also a member of her local water user group that the Khulna Water Supply and Sewerage Authority established to help manage the new community taps across the city. Together, they make up a water user group that looks after community hygiene, maintains the tap, and collects each household's share of the monthly water bill. Akter's household pays about Tk100 monthly toward the water bill.

Before the community tap and treated water were available, most families were in debt for medical treatment for water-related illnesses, Akter said, but that debt has subsided.

Women, who were never available to contribute monetarily to their households, can now work from home. Some women are sewing, and others sell handicrafts they have made at home in their spare time. "I am helping one of my neighbors to make some handicraft that we sell locally. I plan to learn sewing, too," Akter said. "For the first time in many years, women of this area are dreaming of doing something other than spending our entire day at the tube well."

Source: Asian Development Bank.

Sharing the burden and relief. The Khulna Water Supply Project provided 250 metered connections for shared tap stands throughout Khulna City. Women in Khulna's Rupsha slum do laundry together, a chore that has relieved them from the hours of standing in line and hauling buckets from a tube well.

IMPACT

A MORE LIVABLE CITY

The KWSP has made a positive and resounding impact on Khulna City. The results have been reported throughout this report, but in summary, Table 8 provides a before-and-after comparison of key indicators of the water supply system managed by KWASA. Clearly, KWASA is entering its second decade of operations in a much stronger financial, administrative, and operational situation. People's access to water is more convenient and the supply of water more abundant and cleaner. Time—typically women's time—spent augmenting supply from more distant sources has been drastically reduced. KWASA is progressing toward full cost recovery of its operations through affordable, pro-poor tariff structure and more efficient internal operations.

ADB's *Livable Cities Operational Priority Plan, 2019–2024*, the companion document to ADB's Strategy 2030, sets out ADB's approach to supporting the efforts of its developing member countries to build livable cities. That approach entails (i) improving the population's access to quality urban services, (ii) strengthening municipalities' capacity for urban planning and to become financial sustainable, and (iii) improving a city's general landscape to be more climate-resilient and ready for disasters. The plan works with developing member countries to create better institutions, policies, and enabling environments.[27] The following sections summarize how the KWSP's has contributed to raising the overall livability of Khulna City.

Improved Access, Quality, and Reliability of Urban Services

The assurance of adequate water supply is essential for attracting new investments in manufacturing and industry, as well as construction, in the city, in addition to contributing to more productive and efficient living. KWASA is closer to meeting its 2025 demand of around 200,000 m^3/day, having increased production and supplies from 119,100 m^3/day before the KWSP to 160,000 m^3/day in piped water supply (110,000 m^3/day from treated surface water and a maximum withdrawal of 50,000 m^3/day from groundwater).[28]

Solar backup. The surface water treatment plant operates on an automated control system and includes sufficient power supply with a backup facility of 250 kW solar system.

The improved water supply also contributes to a healthier and more productive workforce. With the improvement of water supply, the spread of the two major and common waterborne diseases, diarrhea and dysentery, have been reduced significantly. Only 6.4% of sampled households have been affected with the occurrence of diarrhea and 6.5% affected by dysentery as against 16.8% of the households by diarrhea and 15.3% dysentery before the project.[29]

[27] ADB. 2019. *Strategy 2030: Operational Priority 4; Making Cities More Livable, 2019–2024*. Manila.

[28] ADB. 2020. *Completion Report: Khulna Water Supply Project in Bangladesh.* Manila. p. 3.

[29] Footnote 28, p. 58.

An analysis of the economic benefits of the improved water supply also found that the average household costs of fetching water for those households who benefited from improved access to either a new household or shared community connection was reduced from Tk622 to zero per month; the valued costs of labor from using hand tube wells was reduced from Tk18,000 to zero per month for new households with pipe connection.

Stronger Urban Planning and Financial Sustainability

The stability and proficiency of KWASA are critical to securing future investments in the expansion of water supply and sewerage systems and sustainable O&M of assets, as well as strengthening resilience to climate impacts and disasters. Since KWASA's establishment, ADB has been providing continuous institutional development support. A cornerstone of KWASA's sustainability is its corporate business plan (CBP), which the KWSP worked to make it a viable plan. As a result of implementing the plan and conducting intensive staff training on new systems, KWASA reports a 30-minute average response time to customers' complaints, has hired for 95% of the posts in the human resource development plan (with equal opportunity for male and female applicants), and is reporting a 95% tariff collection rate. KWASA anticipates reaching full cost recovery levels by 2025.

Improved Urban Environments, Climate Resilience, and Disaster Management

The KWSP has strengthened Khulna City's resilience to the impacts of climate change on its water supply. KWASA has been able to reduce its groundwater abstraction from 119,000 m^3/day before the KWSP to 50,000 m^3/day and maintain its maximum drawdown level to 6 m. The city no longer has a need for deep aquifer abstraction, safeguarding those fragile subterranean waters. The KWSP had initially planned on rehabilitating deep tube wells, but KWASA determined that to be unnecessary because of the increased supply from the surface water intake and treatment plant.

Table 8: Summary Profile of Khulna Water Supply System and Operation

Profile Indicators	Pre-Project (2010)	Post-Project (2019)
Population with access to treated piped water supply (%)	<20	65
Hours of piped water supply per day (hours/day)	5.3	24
Water supply per capita per day (lpcd)	45	113
Average daily minutes spent fetching water (minutes/day)	90–120	<20
Total KWASA groundwater abstraction (MLD)	119	50
Total KWASA production capacity (MLD)	69	160 (110 MLD from surface water and 50 MLD from groundwater)
Nonrevenue water (%)	36	20
Average tariff (Tk)	68/month (flat rate)	6.91/m^3 (volumetric)

KWASA = Khulna Water Supply and Sewerage Authority, lpcd = liter per capita per day, m^3 = cubic meter, MLD = million liters per day, Tk = taka.

Sources: ADB. 2011. *Preparing the Khulna Water Supply Project*. Consultant's report. Manila (TA 7385); ADB. 2020. *Completion Report: Khulna Water Supply Project in Bangladesh.* Manila.

First-time household connection. Sultana Parvin, 55, belongs to a household that received a first-time private water connection from the Khulna Water Supply and Sewerage Authority as part of the ADB-supported Khulna Water Supply Project. She said her health has improved dramatically since she no longer uses the heavily salinated groundwater.

Impact Story 3

A First-Time Connection, a Life-Changer

Sultana Parvin remembers when the groundwater in Khulna City was not as salty, when it was plentiful, and did not make people sick. She remembers when tube wells and ponds were reliable water sources for cleaning, cooking, and drinking. But over the years, the water quality and availability within the city deteriorated until it was practically unusable.

"No one could drink water from the previous water sources. It tasted bitter as if we poured four spoons of salt in one glass of water," Parvin said.

Parvin said that women would have to spend the entire afternoon in front of the tube well in the nearby field to collect one bucket of water.

"We had itching, rashes, and severe allergies from using saline water," Parvin said. She watched her son's health deteriorate when he returned home to Khulna after being away for college.

Parvin's family is one of the households that received a household water connection from the Khulna Water Supply and Sewerage Authority (KWASA) for the first time. In July 2019, the Asian Development Bank-supported Khulna Water Supply Project was completed, delivering treated surface water to 40,000 metered connections. The new surface water supply also freed up more groundwater for households and communities that must still rely on groundwater while waiting for future network expansion.

"The day we first got the water connection, we felt our lives change," Parvin said. "My health has improved a lot."

Parvin's husband died from coronavirus disease (COVID-19), yet she still feels her community would have been worse off without a continuous water supply to fight the spread of the virus.

Parvin said she paid Tk50 to water vendors every day, in addition to the hours she spent to arrange, wait, and haul the delivered water, compared to about Tk300 she now pays monthly to KWASA for piped, treated water supply. Parvin said she no longer suffers from persistent back pain from hauling water. So instead of spending her evening hours either strategizing over or collecting the next day's water, Parvin says she can afford evening strolls and rest.

"I don't feel anxious anymore. Without clean water, life is miserable. The access to clean water supply now is helping women to do other activities for themselves and their families. Now I feel more confident and independent," Parvin said.

Source: Asian Development Bank.

Impact Story 4

Women Speak Up on the Impact of the Khulna Water Supply Project

Focus group discussions and interviews with 31 women from three slums in Khulna City rendered the following individual experiences with empowerment and equality because of the Khulna Water Supply Project. Women shared similar positive experiences from training and awareness activities. They learned to reduce wasteful water use practices and to promote health and hygiene. They also found new opportunities for income, making them more confident and independent. They earned more decision-making power within their families and experienced renewed social standing within their community.

Increased capacity to voice opinion

"Before the installation of community water taps, I had no opportunity to share my opinions outside my family and no public relations. I also did not engage in any committee or income-generating activity. The project allowed me to link with the WUG (water user group) and I became its secretary. I learned a lot from the O&M (operation and maintenance) training and awareness-raising meetings. It boosted my confidence. Now I know how to maintain a community tap and whom to contact if there is a problem. I can now guide the community on how to reduce the misuse of water, operate and maintain the community tap, and promote personal and environmental hygiene. Using the saved time from water-related drudgery, I have started tailoring and cloth trading business where I earn Tk5,000 per month. I can use this money however I want to and help my family and daughter's education. The attitude of my family and community towards me has changed. Now my husband and other family members respect my decisions, I have gained a respectable position in the community as well. In case of any community issue, my community even relies on me for solution."
—Parveen Begum, age 40

Connected with income and opportunity to save

"I have three children aged 12, 8, and 3 years. My husband is a skilled laborer. It was tough to manage my family expenditure with my husband's income only. The access to uninterrupted water supply enabled me to engage in income-generating activity. With the saved time, I run a small *pitha* (indigenous cake) shop and earn Tk10,000 per month. Using this income, I can manage better food and school lunches for my children including other household necessities. The access to safe tap water instead of unsafe water hydrant and tube-well water coupled with the increased knowledge on personal and environmental hygiene reduced our monthly medical costs. All these opportunities helped me to save Tk1,200 per month. Since my income contributes substantially to family well-being, my husband supports me in running the shop. We need not to worry anymore about daily food and necessities."—Fahima Begum, age 30

Decreased accidental risk and combat domestic violence

"We are a six-member family including my husband, two children, and elderly parents-in-law. I used to spend more than half a day to walk to a distant tube-well to collect water, especially drinking water, and stand in a long queue. Thus, I could serve lunch for my family almost evening time. This annoyed my husband, children, and parents-in-law. My husband often scolded and beat me because of this. My daughter tried to help me fetch water but one day she slipped when using hand-operated tube-well and broke her hand. She had to be absent from school for a long period. My sister also had a miscarriage while collecting water. My mother-in-law occasionally collected water, but it resulted in persistent back pain. I had to nurse her because she became sick, increasing my workload. Our life was very miserable. This changed when water was installed in our home, I save time and energy. I can do my household chores on time including serving food. My children and parents-in-law can also wash the dishes and clothes themselves. This helped me to find work as a household helper where I am now earning Tk3,000 per month. My husband and my parents-in-law no longer abuse me. They are happy that I am earning, and they even help me with the household chores so that I can work."—Khukumoni, age 30

Improved water access gives leisure time and increased social cohesion

"We had to stand in a long queue to collect water from the roadside hydrant or tube-well delaying a lot of our daily household chores. Every day, women quarreled about who would get to collect the water first. Sometimes, the quarrel became serious and created tension in the neighborhood. With the uninterrupted flow of water, the queue is now no longer a long one. The water collection point has become a center of attraction and instead of quarreling, we enjoy the company of other women who come to collect water. It has become a marketing network for women as well. My next-door neighbor started the clothing business, and she brings her samples here in the water point to show the women and this way she is making a good amount per month. Now we feel and intend to help each other. Last month, my son had a severe stomachache while my husband was outside the city. My neighbor helped to take my son to the hospital and other neighbors helped me to take care of my family during this time. We have become more cohesive in our community."—Kohinur Begum, age 37

Source: ADB. 2020. *Technical Assistance Completion Report: Supporting the Khulna Water Supply Project in Bangladesh.* Manila.

Ensuring operation stays 24/7. ANM Rezanur Rahman is responsible for operation and maintenance at the new intake facility constructed under the Khulna Water Supply Project.

LESSONS

WHAT OTHERS CAN LEARN FROM KHULNA'S EXPERIENCE

Cities and water supply service providers across South Asia, as well as the wider region, face a similar challenge as Khulna City with salinity intrusion and groundwater overextraction. As cities and water supply service providers shift from groundwater reliance to surface water development, the structure of their service organizations change radically, along with staff needs and skills sets. The KWSP provided KWASA with the opportunity to develop a sound business plan, which had to include debt servicing to ensure full financial sustainability. The business plan also accounted for KWASA's need for more staff and training. The proposed organogram represents the required staffing of the new system. An effective training program for staff will ensure proper operation, maintenance, and administration. These are all major components of change management in a system shifting to new modes of water source development and modern water supply service delivery.

The KWSP had the exceptional overall challenge in that the implementing agency, KWASA, was a newly established water supply service provider. The challenges it faced were almost unavoidable since KWASA had limited experience with international development partners. "KWASA was not acquainted with the development partners' procedures, and suddenly, with this project, it was having to work with both JICA and ADB, which had different but compatible processes," said Rafiqul Islam, former ADB senior urban project officer.

Though KWASA was a young entity, the work ethic and professionalism of its experienced leadership was a major success factor. Mohamed Abdullah, KWASA's managing director, is considered by many a tireless champion of KWSP. "He is very committed and sincere, and I never saw him compromise his standards," Islam said. KWASA and ADB officials say the selection of qualified consultants and contractors helped compensate for KWASA's capacity gaps and grow the institution during the implementation through on-the-job and customized training.

Study the Problem as Upstream as Possible for Better Design, Greater Readiness

One of the lessons from KWSP is the value of "upstream studies" for designing the project. As described in this publication, the various studies undertaken by the government, independent organizations, ADB, and JICA are examples of detailed and diligent analysis undertaken to identify various options, understand the advantages and disadvantages of such options, and consider technology-based solutions, inclusive of cost–benefit analysis. Water quality assessment of various intake points done by JICA also provided a prudent selection of the intake site. ADB also supported a groundwater assessment and studied climate adaptation options by using its TA resources. Such diligent upstream studies may be overlooked by some projects in the interest of time or mistaken certainty based on historical bias or outdated information and knowledge.

"There were a lot of extraordinary studies done for this project," ADB's project preparation team leader Masayuki Tachiiri recalled. "JICA spent a lot of time and money to do its feasibility studies well and as quickly as possible. ADB prepared the corporate and climate studies, which was our value addition to the project." Tachiiri acknowledged, however, that not every project has the resources for extensive studies. Government clients are often not willing to borrow for the studies, and so, they rely on ADB's grant funding, which is limited. The KWSP had extraordinary resources in its $720,000 TA to study climate scenarios and identify climate adaptation options for Khulna City.

LESSON Taking time to conduct the upstream studies as done for KWSP will result in better designed projects and ensure a higher project-readiness of implementing agencies.

Anticipate Challenges, Advance Action if Possible on Land Acquisition

Most of the project's principal managers from all sides—ADB, the government, and consultants—attribute their greatest implementation challenge to land acquisition and resettlement compensation. The KWSP needed to acquire 12 sites, the largest site being 26.3 hectares. Available land was scarce in Khulna City that was within a convenient, feasible, and economic distance of the designed system. About two-thirds of the land identified for KWSP was owned by one family willing to sell to the municipality. The other smaller landholders were less willing.

The KWSP faced significant initial delays from residents and advocate groups who objected the project's resettlement plans. Elma Morsheda, ADB infrastructure specialist said, "Estimating the time required for the land acquisition was difficult because KWASA did not have experience acquiring land following ADB's safeguard policy."

Because of his influence and popularity, KWASA requested the Khulna City Corporation (KCC) Mayor Talukder Abdul Khaleque to meet personally and individually with landowners. "I had to assure them that they would receive fair and on-time payments," the mayor said. "I had to appeal to the greater interest at stake for Khulna City." The mayor served as the chairperson of KWASA board of directors during majority of the implementation period and could speak knowledgably and authoritatively about KWSP to the public. Other political leaders, public representatives, and larger landholders came forward to support KWSP and negotiate the land acquisition. KWASA also contracted an NGO to raise awareness about KWSP, address residents' questions and concerns, and implement the resettlement plan. Together, KWASA, district administration, the mayor, and public representatives were able to implement resettlement plans. Land transfers from other government agencies to KWASA proved to be more time-consuming than purchasing private land because of the government procedures and clearances. In many cases, the landowners also took a long time to provide proof of land ownership, which was required for land acquisition and resettlement payments. "I have to say that KWASA and the whole implementing team were rather diligent and systematic in dealing with these challenges," Morsheda said.

Kamaluddin Ahmed, the project director, counts land acquisition among the project benefits because people's resettlement has improved their livelihoods and access to reliable water supply services. KWASA is also far more experienced now in managing land acquisition and resettlement, which is critical for the ongoing ADB financing in Khulna's sewerage sector.

ADB and its clients can now take advantage of the "advanced action" option when projects are in their early inception phase. Advanced actions enable capacity building of the government entities that are likely to be implementing near-term ADB-financed investments. Advanced actions may also be taken to secure legal approvals and procure feasible land that will be needed for future ADB investments (advanced actions must follow ADB's policies or be subject to retroactive correction actions). Advanced actions were not available to KWASA then.

LESSON Implementing agencies that are new to the resettlement policies and procedures of international development partners should expect organized public resistance and possible legal actions against resettlement. Additional training in this regard will be needed for implementing agency staff. Implementing agencies should also advocate for the engagement of NGOs to assist in raising awareness about the project and the resettlement policy. Ultimately, the implementing agency should aim to complete as much of the land acquisition and resettlement activities as possible in advance of the official project implementation period to avoid delays.

Communicate Early, Often, and Clearly on Intergovernmental Approvals

If the resettlement work was the team's most difficult task, acquiring intergovernmental approvals was the team's most protracted effort. The KWSP faced consequential delays from securing the necessary permissions needed to lay the transmission mains. The transmission mains were designed to be laid 2.7 m away from the road embankment using the right of way, but the Roads and Highways Department proposed 21 m from the road embankment, which would have caused significant resettlement activities of mosques, temples, and schools, among others. The KWSP also needed to secure right-of-way permissions from the Bangladesh Railway for the laying of the treated water transmission main.

"The permissions took a long time," Abdullah said. "There were misunderstandings over various requirements and concerns over future impacts. We shared all of our plans, did joint site visits, and had numerous meetings." The discussions even reached the ministerial level in Dhaka.

Ultimately, the Roads and Highways Department and Bangladesh Railway approved KWSP's plans and signed the required memorandums of understanding. Morsheda credits KWASA Managing Director Md. Abdullah. "He was very effective in coordinating with the relevant government entities and ensuring early actions," she said.

LESSON Communicate early and often with systematic information on the project with other government entities of which memorandums of understanding and approvals will be needed.

Manage Expectations of Candidates to Avoid Perennial Vacancies, Turnover

KWASA as well as the project faced major challenges in recruiting both KWASA staff and project consultants. ADB's project preparation team leader Masayuki Tachiiri recalled, "Recruitment was really difficult. The municipal staff who had been assigned to positions with the water supply were given the choice whether to transfer to the newly established KWASA and many chose not to transfer. We also wanted KWASA to be staffed with the right people, with the right skills. It was a real challenge to recruit management and real water engineers."

KWASA and project positions were to be filled from the local job market, yet Khulna City is not home to many (or enough) water experts. Professionals did not want to relocate to Khulna. The travel logistics between Dhaka and Khulna are also tiresome. There is no airport in Khulna City, and the 8-hour drive from Dhaka to Khulna is not a comfortable trip. "We tried to recruit former Dhaka WASA employees and consultants," Islam said. "But they had enough work in Dhaka." KWASA was also limited to offering

government salary rates, not market rates, so, Islam said, "Why should professionals go to Khulna when they can get market rates in Dhaka?" Eventually, ADB successfully advocated for market rates, attracting the first viable project director. The challenge then became retaining nonlocal hires.

Unforeseen, unexpected challenges to a job, such as off-site office space or limited housing options or arduous travel and communication logistics are disincentives for unprepared new hires and consultants to continue in their positions or value the opportunity. The high turnover rate of consultants and prolonged vacancies affects timely progress of project deliverables, but also leads to unsustainable workloads on management and other consultants. "KWASA staff stepped up and took responsibility for a lot of tasks that consultants normally would have done in other projects. They would work from 8 a.m. to 10 or 11 at night," Morsheda said. "They learned a lot this way, but they also risked burning out on the job."

Tachiiri emphasized retention as a systemic challenge. "I still don't have a good solution to the recruitment problem, but this is a serious issue on projects, and not just in Khulna. This is common," he said, "Projects train people for the project and then they take their skills elsewhere, because they are in-demand skills."

Beyond an institution and project surviving weak or absent consultants, institutions (especially new ones like KWASA) face longer-term losses. Morsheda explained, "Consulting firms need to be aware that the lack of quality consultants and consistency affects the transfer of knowledge and technology to the implementing agency staff who will be left behind after the project and should be learning from good consultants in place." Kamaluddin Ahmed, KWSP project director (now the deputy managing director of KWASA) agreed that KWSP suffered at times from the quality of consultants. "We know now," he said, "how to express our expectations more clearly and upfront to potential contractors."

Eventually, KWASA resorted to bringing consultant-candidates residing in other cities to visit Khulna first to personally see the city, the working conditions, etc. "That helped!" Islam said in attracting some consultants, but retaining staff, even for the project director position, for the duration of the work remained a challenge throughout the project.

LESSON Consultants recruited to be part of bids or potential staff to fill a vacant position need to understand the logistics, workplace conditions, and technical expectations to ensure successful recruitment and performance. ADB, implementing agencies, and consulting firms should leverage their respective roles and responsibilities to ensure that prospective consulting firms, their confirmed and potential individual consultants, and other individuals being recruited outside a firm's terms of reference understand all realities of the job or position—not just the technical skills required—in order to manage expectations and successfully retain valuable professionals.

Give New Implementing Agencies Additional Project Implementation Time

Originally, the TA attached to KWSP was to be implemented over 7 months to support KWASA during the initial project stage, in particular, to strengthen KWASA's business strategy. Seven individual consultants were engaged to support KWASA in procurement, financial management, and safeguard areas. The TA was extended to 38 months (with no additional cost requirements) as KWASA's institutional and staff capacity needs became more apparent. The first 12-month extension was approved to engage an NGO to assist

KWASA in implementing the resettlement plan and to hire project management consultants to provide additional support to the project management unit. Their contracts were extended for another 12 months to provide additional capacity development and implementation support. KWASA also requested a 14-month extension to hire a firm to conduct a feasibility study for a wastewater management system and prepare a related master plan for Khulna City, which has informed ADB's ongoing investment in KWASA's sewerage sector.

LESSON Implementing agencies with limited experience in designing or implementing large infrastructure projects or internationally financed projects require more TA resources and time to implement, as the scope of needs changes and grows over time.

There Is No Substitute for a Quality Contractor

A quality contractor can leave a legacy and impact beyond any single project. Morsheda credits the agility of some of the project's contractors in making up for time lost without compromising quality. In fact, Morsheda credits some contractors with improving quality and avoiding complications they detected in the original designs they were given to follow. "The contractors saw flaws in the design and recommended changes (which were accepted)," she said, listing off several commendable qualities in the contractors. "They also trained local labor that have now become a part of the local skilled labor force, and they trained a lot of female laborers. There was technology and skill transfer, for example in learning pipe joining, that will be very helpful for future projects. Khulna will not need skilled labor from outside."

LESSON Careful selection of contractors is important not only for timely and quality implementation, but also improved design. Value contractors who demonstrate a detailed reading of the bid documents, ask questions of the basic designs, visit the project sites to ground-truth design, and recommend further study or other design options. Also, value the locally hired laborers for future work to utilize the skills and experience they have acquired from the project. Develop a performance-based database of quality local subcontractors, consultants, and laborers for future work.[30]

Larger Packages Improve International Competitive Bidding

KWASA leadership has said that the international bidding process was arduous and complicated because KWASA had never engaged in international competitive bidding to ADB's procurement standards. KWASA found that civil works for some of the conveyance works could have been grouped into bigger packages in order to attract contractors with international reputations, higher qualifications, stronger financial resources, and more experience in large civil works contracts. This would have also reduced the risk of contract implementation and the time in managing a large number of contracts. In addition, taking additional time and careful preparation of bid documents and bid reviews will help recruit quality contractors.

[30] For more information on good practices in procurement and contract management for urban development projects and agencies, read how the Rajasthan Urban Infrastructure Development Project successfully resolved issues and developed model systems: ADB. 2021. *Rajasthan Rising. A Partnership for Strong Institutions and More Livable Cities.* Manila. https://www.adb.org/publications/rajasthan-rising-strong-institutions-livable-cities.

LESSON ADB project preparation teams need to carefully evaluate the implementing agencies' capacity for international procurement and contract management. Larger packages may attract more competent international bidders, while numerous smaller packages may overwhelm the implementing agencies. The size of individual contract packages needs to be commensurate with the market and the implementing agencies' experience in designing and evaluating bids and supervising them during construction.

Community Water Taps or Individual Water Connections?

ADB's preference is for individual household connections, which are the optimal choice for increasing the socioeconomic benefits of water supply. The spatial limitations of Khulna's streets and low-income areas were a challenge for KWASA to install household connections under the KWSP. In place of household connections, the network included 250 new metered connections to shared community water taps (piped, metered, treated surface water) for around 10,000 households. KWASA organized 250 WUGs to support the O&M of each meter. Some densely populated communities did not even have space for installing the overhead tank.

LESSON Rigorous scoping of low-income communities within the project area is important to test the feasibility of project ideas and plans. During the project design phase, consultations are also important to conduct with target beneficiaries, especially women, who are primarily responsible for water collection.

Help Women Comply with Water Connection Requirements

According to KWASA regulations, to qualify for an individual water connection with a water meter, applicants must present their land ownership document, tax payment paper of KCC, and national identification card as part of their application. Many households headed by women were not able to submit the papers on time. In response, KWASA adopted a special measure: individual water connections were provided to households headed by women on condition that they commit to providing the required documents later.

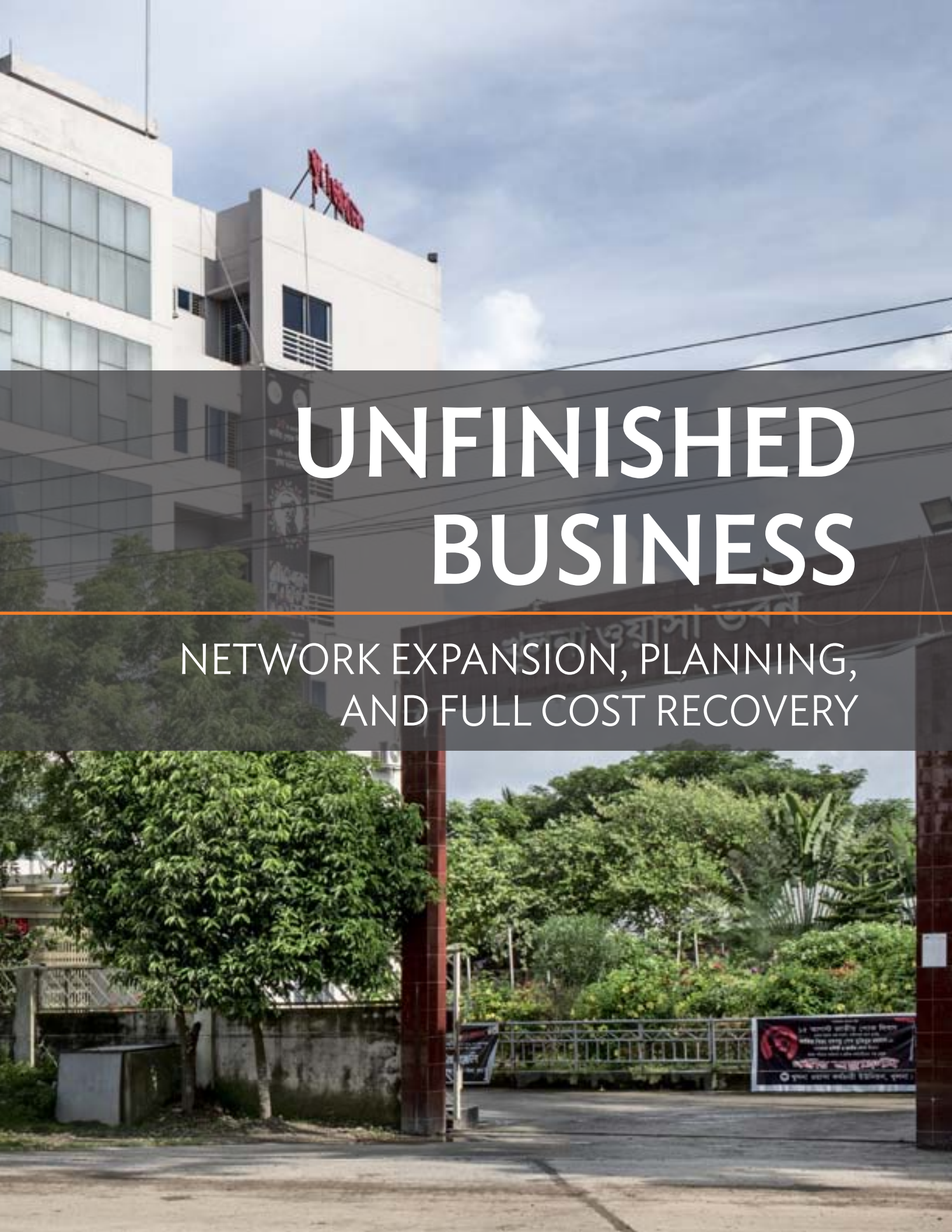
LESSON Implementing agencies need to review regulations and develop a gender equality strategy to make water supply more accessible to women and disadvantaged groups, especially in low-income communities.

Engaging Women in Construction and Maintenance Pays Off

The project initially faced challenges in engaging women in construction and maintenance work due to lack of interest among the contractors. After the project sponsored orientation workshops for contractors, two contractors hired women laborers and reported that women were more focused and completed the work quickly.

LESSON Women can also do construction work. As most construction projects also require technical skills, promoting employment in this sector should be extended to skilled women workers.

KWASA headquarters. ADB financed the construction of a dedicated 6-story building for the Khulna Water Supply and Sewerage Authority (KWASA) and two 2-story zonal offices. KWASA headquarters houses a central control room that receives remote monitoring data from across the system through wireless connections and is technologically capable of adjusting operations.



UNFINISHED BUSINESS

NETWORK EXPANSION, PLANNING, AND FULL COST RECOVERY

Interviews with key stakeholders of the KWSP identified opportunities for KWASA and development partners to further strengthen the coverage, operation, and sustainability of water supply services in Khulna City.

Expanding Household Connectivity

The KWSP improved household connection coverage from less than 20% before the project to 65% after the project. Households that do not gain access to the new surface water supply are able to access to improved quality and availability of groundwater. In its post-project review of the KWSP, ADB found that KWASA still needs to extend the network to another 21,000 connections for complete coverage in the city, as well as keep pace with demand as it increases with rapid urbanization in Bangladesh.[31]

Around 35% of Khulna City households still not connected to the household distribution system are in locations within the service area that are difficult to reach due to congestion and distance from the network, making the connections more costly. Sudhir Kumar Ghosh, project management consultant, said KWASA is working step-by-step to further reduce the city's use of hand pumps and provide pipe water supply gradually to all households. The communities relying on hand pumps did benefit from the project through more available groundwater supplies; but this remains less than ideal. KWASA needs to expand the surface water treatment plant and distribution network to achieve 100% access to piped water supply within its service area.

A Longer Horizon for Corporate Business Plan

The CBP has not yet been submitted to the government for approval and requires substantial updates before submission as it was prepared only up to 2020. In lieu of the government's official approval, KWASA has relied on legal provisions under the WASA Act to implement the necessary tariff increases in order to progress toward its goal of achieving full cost recovery. KWASA has also recruited staff called for in the CBP with specific approval from the government. KWASA reports that it has implemented other major recommendations of the CBP such as the outsourcing of meter reading and billing. Securing the government's approval of the CBP would enable KWASA to more confidently and efficiently implement its schedule of tariff increases and hiring. The tariff structure and organogram are two important aspects of the CBP that drive the quality of KWASA's O&M of the newly established water supply system. But, to submit the CBP for approval, KWASA must update much of the data in the current plan (such as its operating costs, revenue collections, nonrevenue water rates, etc.) in order to justify its financial and human resource needs and plans.

Enhancing Operational Sustainability

The CBP estimates annual O&M expenditures to be $3.25 million from 2025 onward, which includes personnel expense, power cost, chemical cost, maintenance cost, among others. Until 2025, O&M costs are expected to be incurred in proportion to the water produced at the newly established surface water treatment plant under the KWSP.

[31] ADB. 2020. *Completion Report: Khulna Water Supply Project in Bangladesh.* Manila. p. 58.

Operation and maintenance. Technician Md. Sohel Rana Gazi does regular maintenance work at the new water intake facility's pump house.

To finance the O&M, KWASA must follow its scheduled water tariff increases. "Our water tariff needs to increase annually for us to keep up with the costs of the system," Kamaluddin Ahmed, the project director, said. "The public doesn't have a problem with the tariff because they are getting better water in return. And our 95% collection rate on bills proves that."

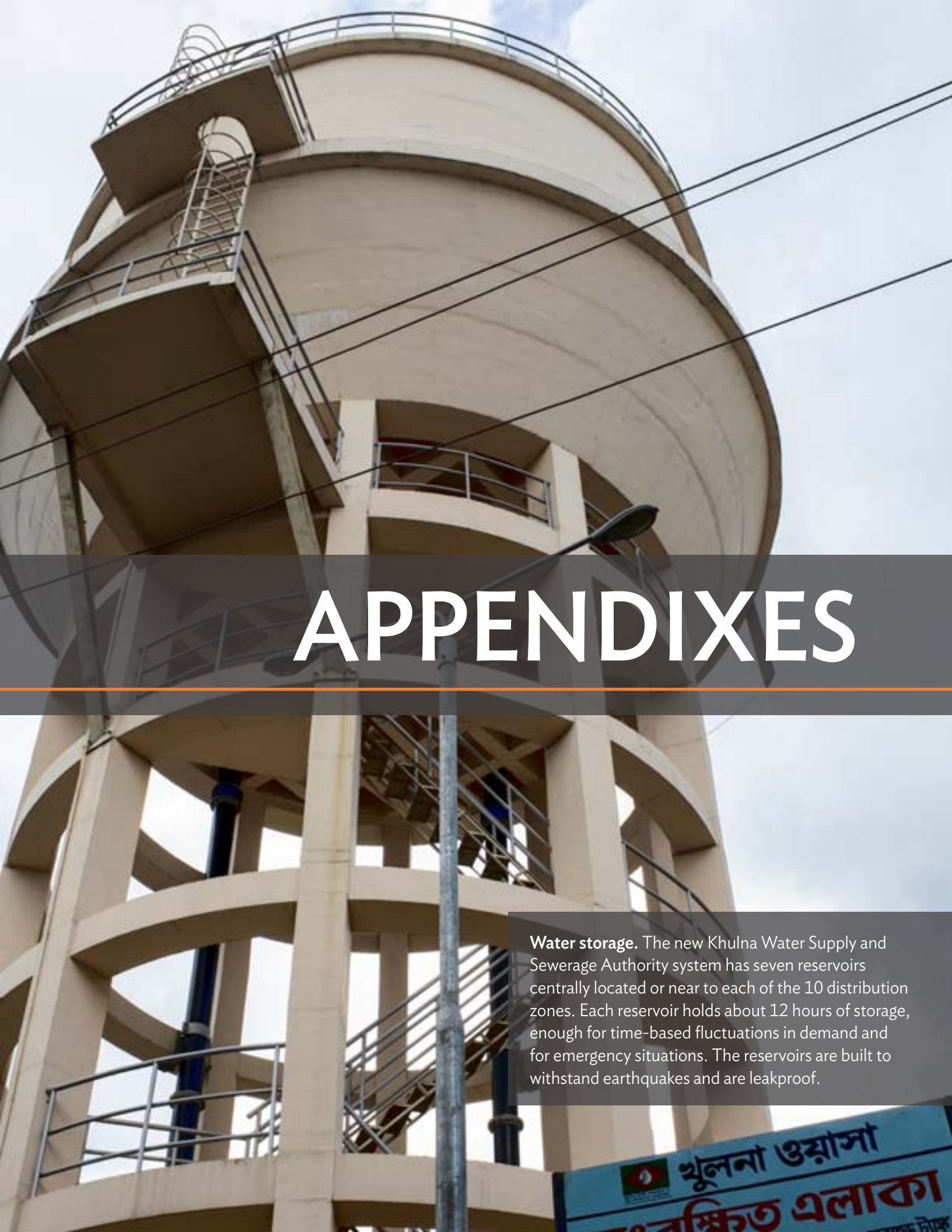
KWASA plans on retaining O&M work internally while many utilities across the region and the world are turning to O&M contracts with the private sector. Rafiqul Islam, former ADB senior urban project officer, questions whether KWASA's human and financial resources can keep pace with the O&M needs of the system. "Is KWASA ready for the costs?" Islam asked. "The operational costs are huge, which is why ADB advocated for a solid business plan, with a tariff structure. This is still going to be a big challenge."

A private operator is a strategy to increase the probability of efficient and professional operations. The construction contract for the surface water treatment plant included 1 year of O&M. KWASA retained some of the contractor's local hires who had worked on the surface water treatment plant, but KWASA Managing Director Md. Abdullah advises that a longer O&M period for the contractor is necessary to better transition the system back to KWASA. The ongoing ADB investments on sewage treatment in Khulna City have proposed a private O&M contract period of 3 years for the sewage treatment plants and 2 years for the networks, after the same contractor(s) complete the construction.

Many larger urban utilities across the region and the world are turning to various types of O&M contracts with the private sector. For example, recent ADB-financed water supply projects in India, Bangladesh, and other countries, often include in civil works packages for both water treatment plant (WTP) and the piped network O&M for 5–10 years, with the contractors responsible for design, build/construct, and O&M.[32] Kamaluddin Ahmed, the project director, believes O&M contracts should not be less than 3 years following the construction of water or sewage treatment plants. This ensures the contractor undertakes quality work and remains mindful that the performance-based targets are met for a longer term, during the operation of the plants. Morsheda explained that a shorter 3-year contract allows the water utility to either extend a contract or change the contractor. KWASA has been recruiting O&M staff on pace with its human resource needs and has partnered with Dhaka WASA on training new staff. KWASA hires staff from the contractor trained and skilled in O&M.

[32] For a full discussion of the benefits of design–build–operate contracts for urban water supply systems, as well as other procurement and contract management lessons and good practices, see ADB. 2020. *Rajasthan Rising: A Partnership for Strong Institutions and More Livable Cities.* Manila. https://www.adb.org/publications/rajasthan-rising-strong-institutions-livable-cities.

APPENDIXES



Water storage. The new Khulna Water Supply and Sewerage Authority system has seven reservoirs centrally located or near to each of the 10 distribution zones. Each reservoir holds about 12 hours of storage, enough for time-based fluctuations in demand and for emergency situations. The reservoirs are built to withstand earthquakes and are leakproof.

APPENDIX 1

KEY INFORMANTS

The following stakeholders from the Khulna City Corporation, the Khulna Water Supply and Sewerage Authority (KWASA), the Asian Development Bank, and a key consultant were interviewed. The impact stories in the main report also relied on numerous interviews with beneficiaries.

Khulna City Corporation

- Talukder Abdul Khaleque, Mayor

Khulna Water Supply and Sewerage Authority

- Mohamed Abdullah, Managing Director
- Kamaluddin Ahmed, Khulna Water Supply Project (KWSP) Project Director and current Deputy Managing Director of KWASA
- Salim Ahmed Khan, KWSP Project Manager and current Project Director of Khulna Sewerage System Development Project

Asian Development Bank

- Masayuki Tachiiri, Director, Strategy, Policy and Business Process Division, Strategy, Policy and Partnerships Department
- Elma Morsheda, Infrastructure Specialist, Pacific Department
- Md. Rafiqul Islam, former Senior Urban Project Officer

Consultants

- Sudhir Kumar Ghosh, Project Management Consultant and former Chief Engineer of the Department of Public Health Engineering

APPENDIX 2

KEY DOCUMENTS

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APPENDIX 3

FACTORS FOR SOURCE SELECTION

By studying the viability of groundwater and surface water, the project development partners determined how the Khulna Water Supply Project (KWSP) could most economically and sustainably meet projected water demand given its ecological limitations with groundwater and challenges with a saline intrusion.

Based on the forecast population growth for Khulna City, the Japan International Cooperation Agency (JICA) confirmed that the city's reliance on groundwater could not meet future water demands (Table A3.1). The city, through KWSP, needed to develop a suitable surface water source.

Table A3.1: Future Water Demand in Khulna City

Indicator	2010	2015	2020	2025	2030
Population	977,906	1,078,000	1,192,063[a]	1,314,000	1,453,118
Domestic water demand (lpcd)	90	97	105	113	120
Domestic water demand (m^3/day)	88,012	104,566	125,167	148,044	174,374
Non-domestic water demand (m^3/day)	21,879	19,986	18,671	16,449	19,387
Total water demand (m^3/day)	109,891	124,552	143,838	164,493	193,761
Leakage after WTP (%)	18	18	18	18	18
Average daily water requirement (m^3/day)	134,013	151,893	175,412	200,602	236,294
Seasonal peak factor	1.15	1.15	1.15	1.15	1.15
Maximum daily water requirement (m^3/day)	154,115	174,677	201,723	230,692	271,738

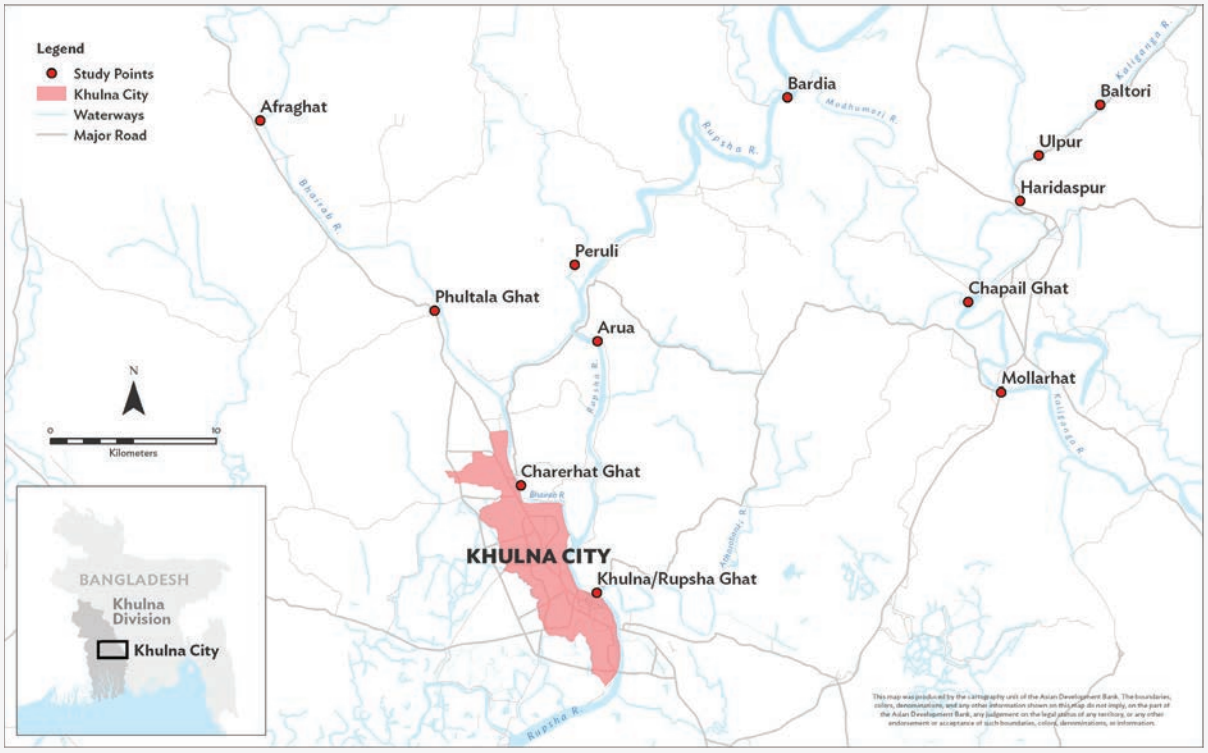
lpcd = liter per capita per day, m^3/day = cubic meter per day, WTP = water treatment plant.

[a] The 2020 population of Khulna is commonly believed to be 1.5 million, exceeding the 2011 census projections due to rapid urbanization and in-migration.

Source: Japan International Cooperation Agency. 2011. *Feasibility Study for the Khulna Water Supply Improvement Project: Final Report, Vol. 1, Summary*, citing population figures from a 2009 ADB report on "Cities Development Initiative for Asia Support to Khulna City Corporation." For more information, visit https://cdia.asia/tag/khulna/.

With the demand analysis pointing the Khulna Water Supply and Sewerage Authority (KWASA) and the project teams toward needing to develop a surface water source for a sustainable supply, the JICA feasibility study team conducted water quality assessments at 12 initial surface water sites on three occasions (October 2009, February 2010, and March 2010) before narrowing the sites down to three (in Mollarhat, Phultala, and Khulna). The following map and tables provide the locations and testing indicators used for choosing the most viable site for the new surface water intake: Mollarhat.

Map A3.1: Locations of Water Quality Analysis



Source: Japan International Cooperation Agency. 2011. *Feasibility Study for the Khulna Water Supply Improvement Project: Final Report, Vol. 1, Summary*. Tokyo.

Table A3.2: Locations, Indicators of Water Quality Analysis of Three Top Surface Water Resource Options

Testing Indicators			Mollarhat		Phultala		Khulna	
Parameters	Unit	Standard	15/03	28/3	15/03	28/3	15/03	28/3
pH	–	6.5–8.5	7.6	8.1	8.5	6.9	6.8	7.7
Turbidity	NTU	10	8	14	110	180	135	195
Total dissolved solids (TDS)	mg/L	1,000	726	880	4,180	7,150	5,472	10,725
Suspended solids (SS)	mg/L	10	9	15	16	24	30	35
Chemical oxygen demand (COD)	mg/L	4	25	35	104	123	95	138
Biological oxygen demand (BOD_5)	mg/L	0.2	6.2	8.9	16	29	14	23
Mercury (Hg)	mg/L	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Lead (Pb)	mg/L	0.05	0	0	0	0	0	0
Arsenic (As)	mg/L	0.05	0.001	0.001	0.004	0.003	0.004	0.002
Chromium (Cr^{6+})	mg/L	0.05	0.01	0.03	0.03	0.02	0.06	0.05
Calcium (Ca^{2+})	mg/L	75	78	29	48	329	379	388

continued on next page

Table A3.2: ***Continued***

Testing Indicators			Mollarhat		Phultala		Khulna	
Parameters	Unit	Standard	15/03	28/3	15/03	28/3	15/03	28/3
Copper (Cu)	mg/L	1	0.07	0.02	0.03	0.05	0.09	0.06
Zinc (Zn)	mg/L	5	<0.05	<0.05	<0.05	0.06	0.4	0.1
Cadmium (Cd)	mg/L	0.005	0	0	o	0	0	0
Chloride (Cl^-)	mg/L	600	373	554	2,568	7,150	3,842	5,650
Sulfate (SO_4^{2-})	mg/L	400	18	23	15	19	24	29
Phosphate (PO_4^{3-})	mg/L	6	0	0	0	0	0	0
Nitrate (NO_3^-)	mg/L	10	5.9	5.4	6.4	3.3	5.2	4.0
Nitrite (NO_2^-)	mg/L	<1	0.007	0.012	0.009	0.01	0.008	0.006
Ammonia (NH_3^+)	mg/L	0.5	0.2	0.4	0.2	0.5	0.7	0.5
Iron (Fe)	mg/L	0.3–1.0	0.3	0.3	11	12	16	15
Manganese (Mn)	mg/L	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Dissolved oxygen (DO)	mg/L	6	3.4	3.6	3.4	3.7	4.2	3.3

NTU = nephelometric turbidity units, mg/L = milligrams per liter.

Source: Japan International Cooperation Agency. 2011. *Feasibility Study for the Khulna Water Supply Improvement Project: Final Report, Vol. 1, Summary*. Tokyo.

APPENDIX 4

OPTIONS ANALYSIS FOR INTAKE SITE

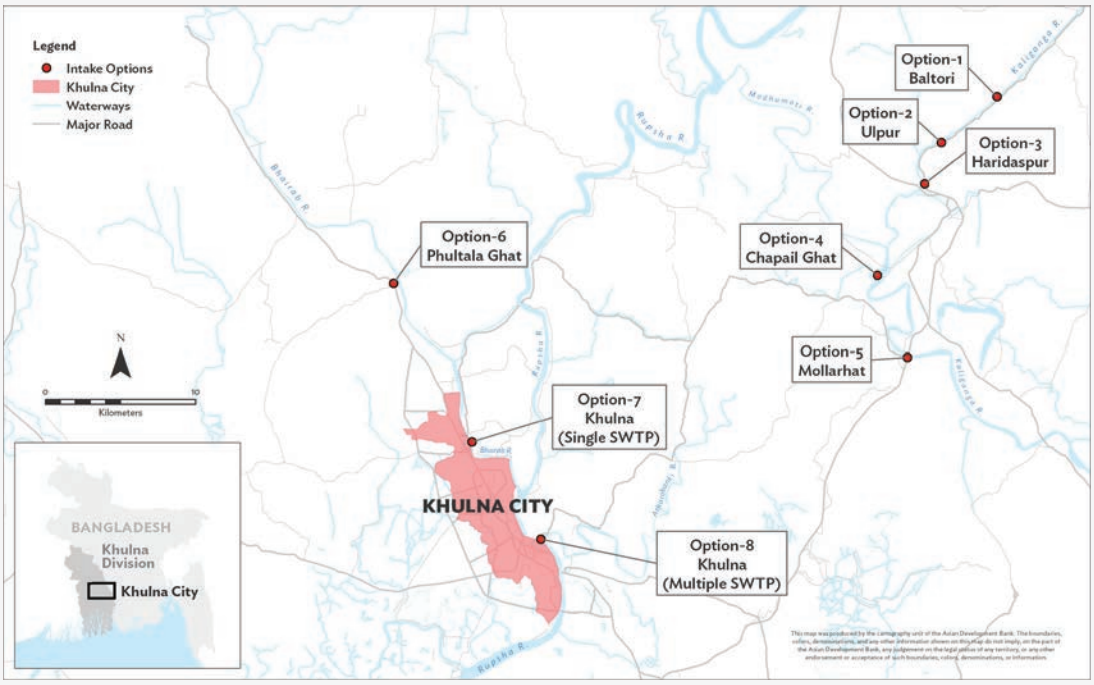
To design the facilities for the water intake, raw water transmission pipe, impounding reservoir, and surface water treatment plant (SWTP), the Japan International Cooperation Agency (JICA) feasibility study team considered the following three raw water allocation cases:

- **Case 1:** River water amount of 110,000 cubic meters per day (m^3/day) is sent directly to the and used as raw water during the non-salinity period (Chloride: less than 1,000 milligrams per liter [mg/L]).
- **Case 2:** River water is sent directly to the water treatment plant (WTP) and used as raw water during the non-salinity period (Chloride: less than 1,000 mg/L), while low-chloride river water will also be stored in the impounding reservoir about 3 months/year.
- **Case 3:** Stored water in the impounding reservoir is sent to the WTP and used as raw water during the high-salinity period (Chloride: more than 1,000 mg/L). High-chloride river water will not be used as raw water.

The comparative data that the team used to determine the ideal intake site is in the following figures and tables:

- Map A4.1 is a map of the eight intake options. For factors shown in the other tables of this appendix, "Option 5: Mollarhat" was chosen as the most cost effective and reliable intake site.

Map A4.1: Eight Intake Options



Source: Japan International Cooperation Agency. 2011. *Feasibility Study for the Khulna Water Supply Improvement Project: Final Report, Vol. 1, Summary*. Tokyo.

- Table A4.1. lists the eight intake options and their related distance and required water treatment, which are key cost factors. The Mollarhat intake point on the Madhumati River is one of the farther options, but as Table A3.2 shows, its water quality was higher, requiring less costly treatment.

Table A4.1: Eight Water Intake Site Options

Case	Option	Intake Source Point	River	Distance from Khulna	Impounding Reservoir	Desalination Process	Number of SWTP
A	1	Baltori	MBR	77 km	–	Not necessary	1
	2	Ulpur		69 km	–	Not necessary	1
	3	Haridaspur		66 km	15 days	Not necessary	1
	4	Chapail Ghat	Madhumati River	60 km	30 days	Not necessary	1
	5	Mollarhat		58 km	45 days	Not necessary	1
B	6	Phultala	Bhairab River	15 km	150 days	Not necessary	1
C	7	Khulna	Rupsa River	4 km	–	Necessary	1
	8	Khulna (2 intake points)		4 km	Not necessary	Necessary	2

km = kilometer, MBR = Madaripur Beel Route, SWTP = surface water treatment plant.

Sources: Japan International Cooperation Agency. 2011. *Feasibility Study for the Khulna Water Supply Improvement Project: Final Report, Vol. 1, Summary*. Tokyo; ADB. 2020. *Completion Report: Khulna Water Supply Project in Bangladesh*. Manila.

- Table A4.2 is a general list of the social and environmental factors used for comparing intake site options, in addition to the assessments on water quality, treatment requirements, and distance to Khulna City.
- Table A4.3 presents comprehensive results of the options analysis, including biological, environmental, financial, social, and technical factors affecting the overall viability of each.

According to the assessments, the best option for an intake site was from the Madhumati River at Mollarhat.

Table A4.2: Social and Environmental Factors for Comparing Intake Site Options

Social Factors, Potential Impacts	Natural Environmental Characteristics	Potential Pollution Impacts
Potential for required land acquisition and resettlement	Topography and geology	Air pollution
Economic activities	Soil erosion	Water pollution to surface water and groundwater
Traffic and public facilities	Groundwater	Soil contamination
Community settlement patterns and potential impact of dividing communities	Hydrological situations	Noise and vibration from construction, operation
Cultural properties (burial grounds, sacred sites, heritage sites, etc.)	Coastal zone factors	Land subsistence
Water rights, land rights, common access, rights-of-way, etc.	Fauna, flora, and protected areas	Offensive odor emissions
Waste disposal sites	Meteorology	
Others hazards and risks	Landscape	

Source: Japan International Cooperation Agency. 2011. *Feasibility Study for the Khulna Water Supply Improvement Project: Final Report, Vol. 1, Summary*. Tokyo.

Table A4.3: Comprehensive Comparison of Water Intake Site Options

Comparison Issue	Case A (Option 1 to 5)		Case B (Option 6)		Case C (Option 7 to 8)	
Intake river flow amount	Ratio of intake flow to river flow: 0.52%–2.02%	D	Ratio of intake flow to river flow: 0.85%	D	Ratio of intake flow to river flow: 0.07%	D
Certainty in water treatment	Some water quality is exceeded standard value; however, these can be purified by universal process.	D	Some water quality is exceeded standard value; however, these can be purified by universal process.	C	Some water quality is exceeded standard value; however, these can be purified by universal process.	C
Raw water transmission pipe diameter	φ1,350 mm, 33 km–62 km	C	φ1,200 mm, 8 km	C	φ1,200 mm, 4 km	C
Impact of salinity and necessity of impounding reservoir	Salinity influence period: 0–30 days Large impounding reservoir is necessary per 0–60 hectares	B	Salinity influence period: 150 days Very large impounding reservoir is necessary per 450 hectares	A	Chloride is treated by desalination process in SWTP.	C
Difficulty of construction work	Large impounding reservoir shall be constructed. Special work (pipe jacking method) is required for river crossing.	B	Very large impounding reservoir shall be constructed in a huge marsh. Very difficult to be constructed with construction machines.	A	No large scale construction work. River crossing work is necessary for Option 8.	B
Easiness of water intake control	Water intake far from Khulna City	C	Water intake near Khulna City	D	Water intake in Khulna City	D
Easiness of SWTP O&M	Normal treatment process is adopted.	D	Normal treatment process is adopted.	D	O&M for desalination process is very complicated.	A
Construction cost	Option 1 = $295 million, Option 2 = $275 million, Option 3 = $276 million, Option 4 = $272 million, Option 5 = $270 million	B	$195 million Construction cost might be higher depending on construction method for impounding reservoir.	B	Option 7 = $310 million, Option 8 = $390 million Due to desalination process, construction cost is the most expensive.	A
O&M cost	$2.39–$2.57 million per year	C	$2.17 million per year	C	$10.15–$10.90 million per year Due to desalination process	A
Social environment	Land acquisition will have some impact	B	Land acquisition will have some impact	B	Land acquisition will have some impact	B
Natural environmental	Topographical and landscape impact may possible to occur	C	Topographical and landscape impact may possible to occur	C	Topographical and landscape impact may possible to occur	C
Pollution aspect	No impact will be expected	D	No impact will be expected	D	No impact will be expected	D
Evaluation	First Priority (Option 5)		Second Priority		Third Priority	

A: Serious issue will be expected B: Some issue will be expected C: Extent of issue is unknown D: No issue will be expected

O&M = operation and maintenance, SWTP = surface water treatment plant.

Source: Japan International Cooperation Agency. 2011. *Feasibility Study for the Khulna Water Supply Improvement Project: Final Report, Vol. 1, Summary*. Tokyo.

APPENDIX 5

DETERMINING RESERVOIR STORAGE

The Khulna Water Supply Project (KWSP) provided seven new reservoirs and 10 new overhead tanks. These reservoirs are centrally located or near to each of the 10 distribution zones. Each holds 12 hours of storage, which is adequate for the time-based fluctuations in demand and for emergency situations. Ten overhead tanks are installed on the ground and regulate flow and pressure. The following table outlines the population of each zone and the capacity of the storage. Demand scenarios for each zone and the required storage requirement was developed for 2020 to 2030.

Table A5.1: Zonal Population, Demand Forecast for Determining Distribution Reservoir Installation

Zone	Number of Wards	Population			Distribution Reservoir Capacity (m^3)	Over Head Tank (OHT) Capacity (m^3)
		2010	2020	2030		
1	2	91,996	105,680	128,760	5,000	650
2	3	129,054	149,580	182,260	13,500	650
3	4	108,962	136,330	166,130		650
4	5	132,460	163,670	206,100	8,000	650
5	2	88,624	102,300	124,640	9,000	400
8	4	82,702	110,070	134,130		650
6	2	80,616	94,300	114,900	6,600	400
7	3	130,404	150,930	183,900	6,000	650
9	3	57,634	84,000	95,240	8,100	650
10	3	75,454	93,140	116,940		400
Total		977,906	1,190,000	1,453,000		

m^3 = cubic meter.

Source: Khulna Water Supply and Sewerage Authority.

APPENDIX 6

TRAININGS

General Training—102 participants

1. Office Etiquettes and Manners

Financial and Accounting Trainings—151 participants

2. Preparation of Debit, Credit, and Journal Voucher (20 June 2013)
3. Double Entry and Accrual Accounting System
4. Bank Reconciliation Statement (18 July 2013)
5. Periodical Financial Reports (5 February 2014)
6. Utility Finance on Accounting System
7. Fixed Assets Management and Depreciation Schedule (16 January 2014)

Geographic Information System Trainings—25 participants

8. Introduction to GIS Technology and Its Application (27 May 2013)
9. GIS/RS for KWASA (31 May–25 June 2014)
10. Customer Data Verification and Plotting on GIS Map (21 June 2016)

Communications and Community Development—42 participants

11. PPA 2006 and PPR 2008 (23 March 2014)
12. Communication Skills on Customer Service (16 April 2014)
13. Media Development, Production, and Use
14. Development Communication (19 May 2015)

Customer Service—14 participants

15. Customer Service Excellence

Water Supply Technology—76 participants

16. Study Tour to Dhaka WASA (28–29 April 2013)
17. PPR Training for KWASA Officials
18. Training on Water Meter Installation and Outsourcing of Billing
19. Water Meter Installation and Management (4 April 2016)
20. Water Meter Installation and Management for Field Level Technicians of KWASA (21 June 2016)
21. Pipe Repair for Field Leave Technicians of KWASA (21 June 2016)

International Study Trips (17 participants)

22. Exposure Visit to India (New Delhi and Kolkata)
23. Participation in the Clean Environment Summit Singapore (13–14 July 2016)
24. Study Tour of KWASA Board Member in Thailand and India (26 January 2020)

From the Ground Up

How Khulna City Shifted its Water Supply System from Salinated, Diminishing Groundwater to Surface Water

Coastal municipalities across the Asia and Pacific region are looking for solutions to worsening salinity levels in their water sources due to overextraction of groundwater and rising sea levels. The transition from groundwater to surface water or conjunctive use can be costly and technically complex. But it is possible, as proven by the Khulna Water Supply Project, cofinanced by the Asian Development Bank and the Japan International Cooperation Agency. The coastal city of Khulna in Southwest Bangladesh developed a new surface water source and avoided the recurring high costs of desalination treatment technology. The project financed an entirely new system—from intake to tap—for 65% of the city's population. The transformative changes from the project were possible with the newly established Khulna Water Supply and Sewerage Authority, only the third of its kind in the country.

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